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A TEXT-BOOK

OF

AGRICULTURAL ZOOLOGY

A TEXT-BOOK

OF

AGRICULTURAL ZOOLOGY

BY

FRED. V. THEOBALD, M.A. (Cantab.), F.E.S.

Professor of Agricultural Zoology, London University; Vice-Principal and Zoologist of the
S.-E. Agricultural College; Grand Medallist and Hon. Member of the Société
Nationale d'Acclimatation de France; Hon. Member Société de Pathologie
Exotique, Paris, the Association of Economic Entomologists of
America, the Royal Horticultural Society; Fellow of
the Society of Tropical Medicine; Imperial
Ottoman Order of the Osmanieh, &c.

SECOND AND REVISED EDITION

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PREFACE TO THE SECOND EDITION.

Since this volume was published in 1899 considerable advance has been made in the subject of Economic Zoology. Consequently many alterations have had to be made in this second edition, and a considerable amount of new matter has had to be incorporated.

The general scope of the work for teaching purposes has not been altered, as it seems to have met with general approval both at home and in the Colonies.

FRED. V. THEOBALD.

Wye Court, Wye,
March 1913.

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PREFACE TO THE FIRST EDITION.

The subject treated in the following chapters, Agricultural Zoology, has perhaps been more neglected in England than any other branch of science applied to agriculture: even the name itself is hardly at present understood. It is true, indeed, that the labours of Curtis, and in later years of Miss Ormerod, have developed one branch of economic zoology—namely, the part played by insects in causing disease amongst animals and plants; it is true also that some of our veterinary surgeons have done excellent work on the other parasitic diseases of animals; but there remains a vast portion of the subject that has neither gained the attention of English scientific men nor been summarised in an English text-book. Agricultural Zoology treats of the life-histories, the habits, the peculiarities of all the animals which affect for good or for evil our stock and crops, whether on the farm or in the garden, and the structure and development of domestic animals. Parasitism plays an important part in this subject, especially in the protozoa and worms; but the economic effects of parasites are not confined to protozoa and worms—the parasitic insects and mites equally take their annual and preventable toll of our flocks and herds. Nor, again, is parasitism always an injurious phenomenon: its beneficial effects are equally marked and equally under control, given only the requisite knowledge. In either case, the necessary thing is an acquaintance with the complex structure and the life-history of both the higher animals we meet upon the farm, which may serve as host, and also of the smaller organisms met along with them, whether injurious or beneficial, parasitic or leading an independent existence. With an injurious insect, for example, there is some period when it is open to attack: our observation should enable us to discover this period, and our science to suggest an appropriate weapon. In the same way our domestic animals are weak at certain points and at certain times: only an intimate knowledge of their organisation and their habits will enable us to apply the corresponding safeguards.

In the following text-book the writer has endeavoured to summarise the habits, characters, and development of the animals that may be met with in farm and garden. Groups possessing little or no economic importance have been but briefly referred to, such as the Cœlenterates, Sponges, and Echinoderms. On the other hand, the structure of one domestic animal, the horse, has been treated at some length.

It is hoped that the book may be of service to the farmer; but it is primarily written for the rapidly increasing class of students in our Agricultural Colleges, &c. In their hands lies the future of scientific agriculture, in the development of which economic zoology must play not perhaps the least part.

My thanks must here be expressed to Sir George Brown, K.C.B., for kindly revising the chapter on the Anatomy of the Horse, and for other help generally; to Dr Hans Gadow for the great trouble he has taken in examining the proof-sheets of chapters xiv. and xv., and for his valuable advice in other matters. The chapters on Mites and Insects have been read over by Mr (now Sir) Charles Whitehead; and to him I tender my grateful thanks, not only for his help in examining the proofs, but also for allowing me the use of some of his excellent figures from the publications of the Board of Agriculture. In connection with the latter, I must here acknowledge the courteous permission of the Controller of Her Majesty's Stationery Office to use the electros, several of which were supplied gratuitously. To Dr George Fleming, C.B., I am indebted most of all: thanks to his generosity, many of the excellent electros of worms, mites, &c., from his translation of Neumann's 'Parasitic Diseases of Animals,' have been lent me for this book, and others he has allowed me to reproduce; but it is especially for the trouble he has taken in revising the chapters on Worms, Embryology, and the parts concerning domestic animals, that I owe him so many thanks. His publishers, Messrs Baillière, Tindall, & Cox, also readily gave their consent to the free use of his figures, and I cannot let this opportunity pass without expressing my thanks for their great courtesy in this matter. Professor Nicholson has very kindly contributed a number of figures from his well-known 'Manual of Zoology,' which greatly add to the value of the work. I must also acknowledge Miss Ormerod's kindness in allowing me the use of fig. 118, and for other advice always so readily given. I must also express my thanks to Sir William Flower, K.C.B., the Trustees of the British Museum, Professor Ritsema Bos, Professor A. D. Hall, and Professor Adam Sedgwick, for either allowing their figures or those of institutions they represent to be reproduced, or for lending the blocks. Mr H. Cousins has kindly revised the part of Appendix II. dealing with insecticides.

Not only in England but also from abroad, especially from America, have I received much courteous and valuable aid, and to one and all I tender my many thanks.

FRED. V. THEOBALD.

WYE, *December* 1898.

Note.—The figures so kindly lent, and those purchased from other works, are here gratefully acknowledged, with sufficient clearness, I trust, for every one's satisfaction:—

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Figs. 82, 102, 103 from the writer's 'Insect and other Allied Pests of Orchard, Bush, and Hothouse Fruits.'

To all who have helped me in this work, by lending their blocks, or allowing their figures to be reproduced, or by lending specimens, I offer my thanks.

F. V. T.

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PART I.

ACHORDATA (INVERTEBRATA)

CHAPTER I.

THE CELL AND SIMPLE ANIMAL TISSUES. THE CLASSIFICATION OF ANIMALS.

The foundation of all living bodies is a structure called a cell. The cell is more or less the unit of life, and may even of itself constitute a definite organism. Most organisms are nevertheless built up of numbers of these cell units, numbers reaching into incalculable figures.

In animals the cells lose their original form, whereas in plants their true symmetry is more or less retained. All the parts, then, of the animal (and plant) are composed of cells collected and joined together in masses, forming the various groups or tissues that constitute the bodies of animals.

All animals originate from either a single cell (asexual reproduction) or the unition of two cells (sexual reproduction).

The Cell-Structure.

The essential part of a cell is the *protoplasm.* This protoplasm is a clear gelatinous substance which is found in all cells, both animal and vegetal. It has been described by Huxley as the "physical basis of life." Generally protoplasm is partially enclosed by means of a constricting membrane, the cell-wall. The protoplasm of each cell is connected with that of the surrounding cells by minute strands passing through pores in the cell-walls.

This living matter may also be observed in a naked or free state (*Amœbæ*).

This all-important living substance is endowed with the powers of contractility and movement, and is subject to such external influences as light, heat, and electricity. Movement takes place by the protrusion of any part of its surface, the protruded parts being known as "pseudopodia," the rest of the protoplasm flowing in a wave-like manner after these processes.

Inside the protoplasm of a cell is a body called the *nucleus*. The nucleus is composed of a more liquid part, the "nuclear fluid," and a more solid part, the "nuclear protoplasm." The nucleus varies in form: sometimes it is round, at others oval, or again it may be elongated and twisted.

Both protoplasm and nucleus are surrounded, as a rule, by a definite layer, which *more or less* retains the contractile protoplasm. The essential part of the cell is the protoplasm, which has the power of independent movement, of metabolism, and of reproduction. All organisms that we shall deal with, excepting the simple Protozoa, will be seen to be made up of numbers of these cells, which become united in various ways, and so form the animal tissues. We know that a cell always originates from a pre-existing cell. The formation of one cell from another takes place chiefly by a process known as *karyokinesis* or "cell-division."

When a cell has received its full share of nourishment—that is, when it has reached maturity—its protoplasm commences to separate into two equal halves. This division is preceded by a corresponding separation of the nucleus, and then the whole cell splits into two cells. During this process of cell-division certain definite changes take place in the nucleus. This body at first is spindle-shaped; its contents are drawn out into longitudinal striæ, when the centre of these striæ becomes thickened and forms an equatorial zone or "nuclear plate." This "plate" then divides, and each half travels to the poles of the spindle, which assumes a dumb-bell shape, then elongates, and the two nuclear masses, the remains of the equatorial plate, become surrounded by a clear fluid. These form the two nuclei at the poles of the spindle. As soon as this has taken place the whole protoplasm constricts in the middle, and the cell divides into two.

There are two other ways in which cells reproduce—namely, by "budding" and by "endogenous cell-formation." "Budding" is when one of the produced cells is smaller than the parent cell. In "endogenous cell-formation" we get the protoplasm and nucleus of the parent cell, splitting up internally into a number of small bodies, known as "spores." These are seen only in the lowest forms of life.

The separation of groups of various cells leads to the formation of the different tissues. Of tissues we make out two chief kinds—namely, vegetative tissues and animal-life tissues. The former carry out the nourishment and maintenance of the body; the latter are those tissues which are characteristic of animals, and whose functions are for movement and sensation.

Of vegetative cell-tissues there are two divisions—(1) epithelial and free cells, and (2) connective tissues. The tissues of "animal-life" are (3) muscular tissue, and (4) nervous tissue.

1. **Free Cells and Epithelium.**

(*a*) *Free or wandering cells* are those that are found floating in some fluid medium. The corpuscles of the blood and lymph are excellent examples of free cells. In the invertebrate blood, which is normally colourless, will be found numbers of pale amœboid bodies. In vertebrate blood these amœboid corpuscles are augmented with red blood corpuscles (fig. 1), round cell-discs which contain the colouring matter of blood—namely,

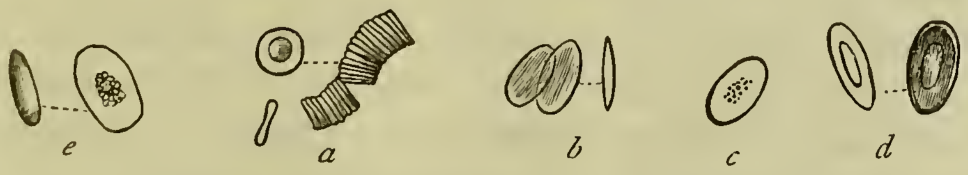

Fig. 1.—Blood Corpuscles of Vertebrata.

a, Of man; *b*, of goose; *c*, of crocodile; *d*, of frog; *e*, of skate. (Nicholson.)

hæmoglobin—a substance which plays such an important part in respiration. Besides blood and lymph corpuscles we find other isolated cells in the body, the ova and spermatozoa, which become detached as single cells from the epithelial walls of the male and female organs, the testes and ovaries. The form, especially of the spermatozoa, varies greatly: in most cases the spermatozoa have a long thread-like tail attached to the nucleated cell.

(*b*) *Epithelial tissues* consist of groups of cells, which in simple layers line the exterior and interior of the body surface. The internal lining is known as "endothelium." There are four chief types of epithelium, each distinguished by the form of the cells—namely, (1) cylindrical, (2) ciliated, (3) pavement, and (4) glandular epithelium.

The lower cells of these cell-masses retain their natural form; but the upper ones may become hardened. Thick stratified layers of such cells occasionally become fused, and produce horns, nails, claws, hoofs, &c. Sometimes the outer walls of the epithelial cells are thickened, forming a "cuticle." These cuticular membranes are perforated by small pores and also by larger passages: in these cuticular pores are placed the hairs and feathers. The cuticular secretions may form a hard shell or case for the organism, an exoskeleton, as seen in the Crustacea and Hexapoda.

Glandular epithelium is that epithelium in which some cells secrete not a solid but a liquid substance. In the most rudimentary cases the gland is formed by a single epithelial cell, the secretion passing out by either a special opening or through the superficial membrane. Several of these cells may arrange themselves around a central space and pour their secretion into it; the gland then forms a blind invaginated sac opening to the exterior or interior by the neck of the whole glandular mass. From this simple gland a compound gland is built up by repeated regular or irregular outgrowths. The terminal portion of each gland is converted into a duct in most glands, for the carrying away of the fluid secreted. Some glands, however, are ductless or blind (spleen, &c.)

2. **Connective Tissues** are those which connect and surround other tissues, and act as supporting and skeletal structures. The presence of intercellular substance distinguishes this group. This intercellular matter is secreted by the whole of the cells which it surrounds, and is very variable both in consistency and in structure. One variety is known as *fibrillar-connective tissue*, in which elongated cells are embedded in a solid intercellular substance broken up into bundles of fibres. In ligaments and tendons the fibres have a wavy outline, and are parallel in arrangement. When the fibrillæ are treated with acids, they swell up, and a second form, which resists these reagents, appears. These threads are *elastic fibres*, and may predominate so as to form *elastic tissue*, which branches and forms a network, sometimes of great strength, such as the *ligamentum nuchæ* of the neck—the ligament by which the head of quadrupeds is held up in a horizontal posture: at other times they spread out, forming the so-called "fenestrated membranes" of Henle in the arteries. The two most important skeletal tissues are cartilage and bone.

Cartilage is a true connective tissue, and may be distinguished by its spherical cells and gristly intercellular substance in which the cells are embedded. We can recognise three distinct kinds of this cartilage—hyaline, fibrous, and elastic. The cells of cartilage are placed in clear round spaces. Its varieties will be pointed out when we come to more special parts. Suffice to say here that it is found in both of the great divisions of the animal kingdom, and may even constitute the entire skeleton of some of the fish (*Elasmobranchii*).

Osseous tissue, or bone, is hard and possesses a high degree of rigidity, through the intercellular substance being hardened by the deposition of carbonate and phosphate of lime, these salts constituting about two-thirds of the weight of bone. The cells (the bone-corpuscles) occupy spaces in this intercellular matter.

Numerous canals (Haversian canals) run through the bone, containing blood-vessels and nerves. The calcareous matter is arranged in concentric rings round these canals, which begin in that highly vascular periosteal layer that circumscribes the whole bone and open into long spaces, the marrow canals, in the axes of the long bones. In all cases bony tissue is preceded by either cartilage or other connective tissue.

The two animal-life tissues are *muscle* and *nerve.* These can be detected in all animals save the very lowest forms, which are apparently nothing but undifferentiated protoplasm.

3. **Muscular Tissue** is contractile: the power of contraction is due, as has already been pointed out, to the protoplasm itself. By differentiation of the protoplasm of certain cells and groups of cells the power of contractility is brought to a higher state of efficiency, and a tissue, the so-called *muscular tissue,* is formed solely for movement. Muscle-cells during movement contract and expand. In some of the lower animals we find cells in which only part of the cell is differentiated into a muscle fibre. A stage further, and we find the whole cell becoming elongated and converted into a definite muscle fibril.

Of muscle there are two kinds, the *striated* and the *unstriated.*

The *unstriated muscle* is composed of flat, elongate, spindle-shaped bodies, which contract slowly and remain in a contracted state for some time. They seldom are more than $\frac{1}{600}$ of an inch in length. They form muscles over which the animal has no control, and are thus called involuntary muscles. This variety is prevalent in the lower animals, but is also found in all high forms of life. Each such muscle-cell has a distinct nucleus.

Striated or voluntary muscle consists of multinucleated masses called primitive bundles. It is composed of long cylindrical fibres, about $\frac{1}{500}$ of an inch in diameter in mammalian muscle. Most or all of the cell protoplasm is converted into a cross-striped substance, due to alternate double and single refractive powers. This striped or voluntary muscle is under the control of the animal will, and can contract with great energy. Almost the entire protoplasmic contents of the cells are concerned in the production of this voluntary muscular tissue. The cells become elongated into long fibres, the primitive bundles; and the nucleus divides and forms numbers of nuclei, each fibre being surrounded by a membrane, the so-called "sarcolemma." The sarcolemma is an elastic sheath. The primitive bundles also arise by the fusion of several cells. Muscular tissue, then, is cell-tissue modified for a certain definite object—namely, movement. There is certain striated muscular tissue called *cardiac muscle*, which forms the walls of the heart, and which is involuntary in action. Cardiac muscle is cubical in form, and has a little side projection from each area.

4. **Nervous Tissue** is found generally with muscular tissue. It forms the seat of will and sensation, and is the means by which stimuli are carried to the muscles to cause their movement. The nervous tissue is supposed to have originated from the ectodermal sense-cells found in the skin, and that, still remaining united to the same, they have grown inwards, and have thus only in a secondary way become united to the muscle-cell, which is *prima facie* contractile. In nervous tissue there are two distinct elements—namely, *nerve-cells* and *nerve-filaments*—which have separate structural differences.

Nerve-cells are found in the brain, in the spinal cord, in the so-called ganglia of the lower animals, &c.; they are really central areas for the nervous stimuli. Each nerve-cell or ganglion cell possesses a very distinct nucleus and nucleolus, and one, two, or more processes, when they are known as uni-, bi-, or multipolar ganglion cells. One root is always that of a nerve-filament.

Nerve-fibres are of two kinds: one variety carries impulses—sensations—from the central organ (cells) to the peripheral organs,—these are called motor or secretory fibres; the other carries impulses from the periphery to the central organs, and are known as sensory fibres. In most cases the sensory nerves are united at their peripheral end with the so-called "end-organs" in the skin, &c., these end-organs being derived from the modified epithelial cells.

Such are some of the modifications that are assumed by cells in the animal kingdom.

The lowest animals, we shall see, possess neither tissues nor organs composed of cells, and yet each organism, although only a single cell, is complete in itself and reproduces a similar species.

The Differences between Animals and Plants.

Living bodies are divided into two groups called "kingdoms," the one the Animal Kingdom, the other the Vegetable Kingdom. Although there are apparently great differences between the two, yet when we come to examine the lowest animal forms and compare them with the lowest vegetal forms we shall observe so great a similarity that it is impossible to say to which kingdom they belong. In fact, there is no hard-and-fast line to be drawn between these two organic groups. Such lowly creatures as *Plasmodium* and *Volvox* are treated by botanists as plants, whilst the zoologist includes them in the Protozoa.[1] It may be said, speaking generally, that animals are capable of free movement and that plants are fixed; but when we examine some of the simplest forms of life this distinction will be found untenable. Animals are endowed with sensation, plants are not, as a rule; but such plants as *Drosera*, *Venus's fly-trap*, &c., surely have this phenomenon developed. Animals have their organs internal, their absorbent surface inside; plants have external organs, and the absorbent surface also external. Yet the Tapeworms (*Cestoda*) obtain their nourishment by osmosis through the skin.

When we compare the tissues of an animal with the tissues of a plant, then we observe greater differences. The cells of the animal are altered in form, whilst those of the plant retain more or less their original appearance. The cell-wall, too, of the animal is nitrogenous, that of the plant is non-nitrogenous. But all this only applies to the higher plants and animals: it cannot apply to those unicellular forms, where, as we see in Amœba, there is *no* cell-wall at all. It is often thought that we can tell a plant by its green colouring matter, *chlorophyll*, but not all plants have this chromatic substance in their tissues; whilst, on the other hand, some animals—such as *Hydra*, *Bonellia* (one of the Worms), and some sea-anemones (*Actinozoa*)—owe their green colour to the presence of this substance. Cellulose is the substance that forms the cell-wall of plants, and is characteristic of the vegetable kingdom; but we also find it in the "tests" or cases of those curious marine animals, the sea-squirts or *Ascidians*. In the higher animals a substance known as *cholesterin* is found: this was at one time considered a purely animal component, but we now know that it is also found in at least one family of plants, the *Leguminosæ* or Pea and Bean family. Generally speaking, animals are nitrogenous, plants carbonaceous; but, as in the prior instances, this also will not invariably apply. There are no definite distinctions, then, between the animals and plants in regard to their chemical constituents. Perhaps the greatest differences are to be found in the metabolism of organisms. We cannot feed an animal on purely inorganic food, whilst, on the other hand, we can so feed a plant. Both must have salts and water; but whilst plants can be nourished with the addition of carbon dioxide and nitrates of ammonia, an animal must have nitrogenous and carbonaceous matter in some organic form and not in a mineral form. An animal absorbs oxygen and gives out CO_2; a plant exhales oxygen which is derived from the absorbed CO_2.

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[1] 'A System of Medicine,' vol. ii. Pt. ii., article by E. A. Minchin—"Protozoa," p. 17. 1907.

Thus we see that there are differences between the plant and the animal, but that many of them do not invariably hold good. There are forms of life which we may fairly say bridge over the great hiatus that separates the horse from the grass upon which it feeds.

THE CLASSIFICATION OF ANIMALS.

The old method of classifying animals was to divide them into two sub-kingdoms, known as the *Invertebrata* and the *Vertebrata*,—the absence or presence, respectively, of an internal skeleton being the character upon which this division was based.

Invertebrates are those animals which have no internal skeleton; but, of greater importance still, they possess no structure known as the *notochord*. The notochord is a primitive axial skeletal rod, found on the dorsal surface. In all invertebrate animals the nervous system is ventral—that is, it is always present on the lower surface of the animal; whilst, on the other hand, the hæmal or blood system is dorsal, the alimentary canal or gut being situated between. Invertebrates may possess a skeleton, but it is always external (*exoskeleton*).

Vertebrates, on the other hand, always possess a notochord, and nearly always an internal skeleton, composed of an axial rod, the vertebral column, besides the cranium, and an appendicular skeleton—the limbs. The vertebral column—the backbone—and the cranium enclose the central nervous system, which is always dorsal, whilst the nervous system in invertebrates is ventral. The hæmal system— the heart—is placed ventrally,—that is, in the reverse position to that in which it is found in the former group.

Just as there are intermediate forms between the animals and plants, so are there connecting links between these two primary groups of animals. A small fish, known as the lancelet (*Amphioxus lanceolatus*), found in the sands of the Mediterranean, has no proper internal skeleton at all, yet it has a notochord and dorsal nervous system.. The groups of *Ascidians*, or sea-squirts, are in their young stages distinctly vertebrates; for the young so-called *Appendicularia* larva has a dorsal nervous system and an axial rod, but the adult Tunicate, as it is also called, is distinctly an invertebrate animal with no notochord and a ventral nervous system.

How, then, can we distinguish these from true vertebrates? At no time do they possess a brain or cranium as we see in the higher animals. They are called, therefore, *Acrania*, to distinguish them from all the other vertebrates, which are known as the *Craniota.* This was the most generally adopted primary grouping of animals, into Invertebrata and Vertebrata; but for many reasons a more recent classification has many advantages over it. This latter is based primarily on the cell-structure of the animal. By it the whole animal kingdom is divided into two primary groups, known as the *Protozoa* and *Metazoa.*

The *Protozoa* are those animals of extremely simple organisation, and whose bodies are composed of a single cell.

The *Metazoa* constitute a group that includes the majority of animals. These are built up, not of one cell or a few cells, but of countless numbers of cells, which form the complicated animal tissues—muscular, nervous, connective, &c. This division will be found to contain both invertebrates and vertebrates.

The **Protozoa** form the first group of animals, the lowest organisms, single-celled creatures, which are, nevertheless, important to us, as many of them produce diseases, such as liver-rot in rabbits, malarial fever, sleeping sickness, redwater in cattle, psorospermosis of the skin, &c., in man and his domestic animals.

The multicellular animals, or **Metazoa**, are divided into the following groups, called classes:—

1. *Cœlenterata*, or Jellyfish, Polyps, Sea-anemones, Corals, &c.
2. *Echinodermata*, or Starfish, Sea-urchins, and the nearly extinct Sea-lilies.
3. *Vermes*, or Worms.
4. *Mollusca*, or Shells.
5. *Arthropoda*, or the Jointed-limbed animals, as Insects, Spiders, Scorpions, and Crabs, &c.

The above are all **Invertebrate** Metazoa. The *Spongidæ*, or

Sponges, may belong to this division; but whether they are to be looked upon as colonies of Protozoa, or Metazoa, there is some diversity of opinion. They seem to present most affinities to the Metazoa, and should doubtless be included in the Invertebrate division of that group.

6. The sixth class of Metazoa include the *Ascidians, Tunicates* or Sea-squirts, the *Amphioxus* or Lancelet, and the worm-like *Balanoglossus.* These form the connecting group between the Invertebrate and Vertebrate Metazoa.

The **Vertebrate Metazoa** are contained in five classes, namely—

7. *Pisces*, or Fish.
8. *Reptilia*, or Snakes, Crocodiles, and Lizards.
9. *Amphibia*, or Toads, Frogs, and Salamanders.
10. *Aves*, or Birds.
11. *Mammalia*, or Quadrupeds and Man.

The above eleven classes of Metazoa may be grouped in two divisions, according to the absence or presence of a notochord. Those without a notochord are called *Achordata*, those with a notochord *Chordata.* The latter, again, are divided into *Acrania* and *Craniota.*

The *Acrania* include, besides the Tunicates, the worm-like creature called Balanoglossus and the quaint little fish-like Amphioxus. These always have at some period of their life a dorsal nervous system and a notochordal rod which extends nearly the whole length of the body; but the nervous system, which develops as an open canal (another character common to vertebrate animals), never expands anteriorly into a brain. In fact, in general appearance Tunicates and Balanoglossus are invertebrates, while Amphioxus forms another stage higher, connecting the lower animals with the Fish. Amphioxus has been described by Couch and others as a fish. The *Craniota*, on the other hand, have the anterior end of the nervous cord enlarged into a brain placed in a cartilaginous or bony box, the cranium, and are supplied with an internal skeleton.

The groups of animals, then, may be tabulated as follows:—

- PROTOZOA
  - Sarcodina.
  - Mastigophora.
  - Sporozoa.
  - Infusoria.
- METAZOA
  - ACHORDATA = Invertebrata
    - *Spongidæ.*
    - *Cœlenterata*
      - Hydrozoa.
      - Actinozoa.
      - Ctenophora.
    - *Echinodermata*
      - Echinuridæ.
      - Asteridæ.
      - Holothuridæ.
    - *Platyhelminthes*
      - Trematoda.
      - Cestoda.
      - Nemertini.
    - *Nemathelminthes*
      - Nematoda.
      - Acanthocephala.
    - *Chætopoda.*
    - *Hirudinea.*
    - *Arthropoda*
      - Peripatus.
      - Myriapoda
        - Iulidæ.
        - Scolopendridæ.
      - Crustacea
        - Malacostraca.
        - Entomostraca.
      - Arachnoidea
        - Scorpionidæ.
        - Araneidæ.
        - Acarina.
      - Insecta (Hexapoda)
        - Coleoptera.
        - Hymenoptera.
        - Lepidoptera.
        - Diptera.
        - Hemiptera.
        - Neuroptera.
        - Orthoptera.
        - Thysanoptera.
        - Aptera.
    - *Mollusca*
      - Mollusca (Proper)
        - Lamellibranchiata.
        - Gasteropoda.
        - Pteropoda.
        - Cephalopoda.
      - Molluscoidea
        - Brachiopoda.
        - Polyzoa.
  - CHORDATA = Vertebrata.
    - ACRANIA
      - Hemichordata (Balanoglossus).
      - Urochordata (Ascidians).
      - Cephalochordata (Amphioxus).
    - CRANIOTA
      - *Ichthyopsida*
        - Pisces
          - Marsipobranchii.
          - Elasmobranchii.
          - Ganoidei.
          - Dipnoi.
          - Teleostei.
        - Amphibia
          - Ophiomorpha.
          - Anoura.
          - Urodela.
      - *Sauropsida*
        - Reptilia
          - Chelonia.
          - Ophidia.
          - Lacertilia.
          - Crocodilia.
        - Aves
          - Ratitæ.
          - Carinatæ.
      - *Mammalia*
        - Ornithodelphia = Monotremata.
        - Didelphia = Marsupialia.
        - Monodelphia
          - Edentata.
          - Sirenia.
          - Cetacea.
          - Ungulata.
          - Proboscidea.
          - Carnivora.
          - Rodentia.
          - Insectivora.
          - Cheiroptera.
          - Primates.

CHAPTER II.

PROTOZOA, OR SINGLE-CELLED ANIMALS.

The Protozoa are the simplest forms of animal life: they are all of small size, of extremely simple constitution, and invariably unicellular. They are animals that have remained as simple cells, to all intents and purposes like the cell described in chap. i. Each cell is physiologically and morphologically complete in itself. Some forms of protozoa are simple drops of sarcode—protoplasm; others have not only a definite cell-wall, but possess the power of secreting calcareous and siliceous shells. These shell-bearing species, or *Foraminifera* (fig. 3, iv. and v.), are present in myriads in the waters of the ocean, their "tests" or shells falling to the floor of the sea as the animals die. Many of these tests are dissolved before they reach the bottom, if the depth of water be very great; yet millions of others arrive safely upon the bed of the sea, and there by slow degrees they form a layer of a white or creamy colour. Of such formation is the globigerine ooze on the floor of the Atlantic and also the radiolarian ooze,—protozoa of the genera Globigerina (fig. 3, v.) and Radiolaria taking the chief part in the formation of these two oozes respectively. Of ancient rocks we know that some of the Chalk has been formed in a similar way, by the slow accumulation on the sea-bed of these and other falling tests. Not only do we find that the Chalk in many instances is built up of these minute organisms, but also that their tiny shells represent genera existing at the present day. What countless myriads of these microscopic organisms must be present in the chalk rocks of our North and South Downs alone, when we consider that thousands go to the square inch.

The Protozoa are divided into four classes: (1) the *Sarcodina*, (2) *Mastigophora*, (3) *Sporozoa*, (4) *Infusoria*.

Sarcodina are protozoa in which the protoplasm is naked and which have no permanent organs of locomotion, but temporary processes called *pseudopodia.*

Mastigophora are more or less of definite form, and have one or more permanent organs for locomotion or food capture in the form of flagella in the adult.

Sporozoa are internal parasitic protozoa which have no organs of locomotion or for the capture or digestion of food. They reproduce only by some means of sporulation.

Infusoria are provided with cilia for locomotary purposes.

CLASS I. SARCODINA.

Although Amœba is specially referred to here it is only in its resting stage that the typical body form is realised, as Sarcodina are typically simple spherical bodies, such as the Radiolaria and Heliozoa, which float freely on the surface of water and have pseudopodia radiating from them in all directions. But in the Mycetozoa—semi-terrestrial protozoal masses which live on rotten tree-trunks, fungi, &c.—the protoplasm forms large creeping masses called *plasmodia*,—the latter including the well-known parasitic disease of Cruciferous plants, "Finger-and-Toe," produced by *Plasmodiophora brassicæ* of Woronin.

These Sarcodina are divided into five sub-classes, the Amœbæa (fig. 2), the Foraminifera (fig. 3), the Mycetozoa, the Radiolaria, and the Heliozoa.

We need only refer to the first here.

SUB-CLASS AMŒBÆA.

They may again be divided into the Lobosa nuda and the Reticulosa. The former include the Amœbæ (fig. 2).

Amœba is a simple unprotected mass of protoplasm or sarcode, which may be found in damp earth and in water. In appearance it resembles a small speck of white, transparent, structureless jelly. If this speck is observed under strong magnifying power, it will be seen to move by throwing out little finger-shaped processes, the pseudopodia (*Psu*). This simple organism is apparently composed of two layers, a granular layer inside and a clear transparent layer on the outside: the former is known as the endosarc and the latter as the ectosarc. These two layers must not be mistaken for two distinct membranes, for they are continuous, only certain granules collect towards the interior. When the pseudopodia (*Psu*) are thrown out we shall see, if we watch carefully, that the granules flow up the centre of the process as it elongates. Three other bodies are to be noticed in this minute creature: first, a small dark oval spot, with a clear border and permanent in shape, situated in the endosarc; this is the *nucleus* (*n*), and it will be found to stain dark-red with picro-carmine. The nuclear substance or chromatin here is a single mass, but it may be divided into portions, yet it can always be distinguished from the body protoplasm or cytoplasm. There will also be seen contracting and expanding a clear space in the ectoplasm; this is the so-called "pulsating vacuole" (*cv*), of which there are two in some forms of Protozoa (*Paramœcium*). The pulsating vacuole is said to be an excretory organ, for uric acid and water have been extracted from these minute cavities. These vacuoles may be looked upon as both respiratory and excretory. Lastly, there are present a number of so-called "food vacuoles" (*Fv*), spaces surrounding the particles of food ingested by the amœba. This proteus-animalcule is neither provided with mouth nor anus. The food can be taken in and expelled at any part of the body. This process can easily be watched if particles of indigo are placed in the water surrounding an amœba: a speck of indigo will be found to be drawn to the protozoan by the pseudopodium, and then it can be watched gradually sinking into the protoplasm until it reaches the endosarc, where it remains whilst the substance (if an organism) is digested, the waste part being expelled through any part of the animal. The food consists of organisms still smaller than the amœbæ are themselves. The granules in the endoplasm are regarded as stages in the upward or downward metabolism of the material of the body. Amœba reproduces by the primitive method of "fission" or division. The nucleus of the amœba divides into two (fig. 2, ii. and iii., *a*), and one of these nuclei, surrounded by part of the original protoplasm, breaks off and floats away; thus one amœba becomes two.

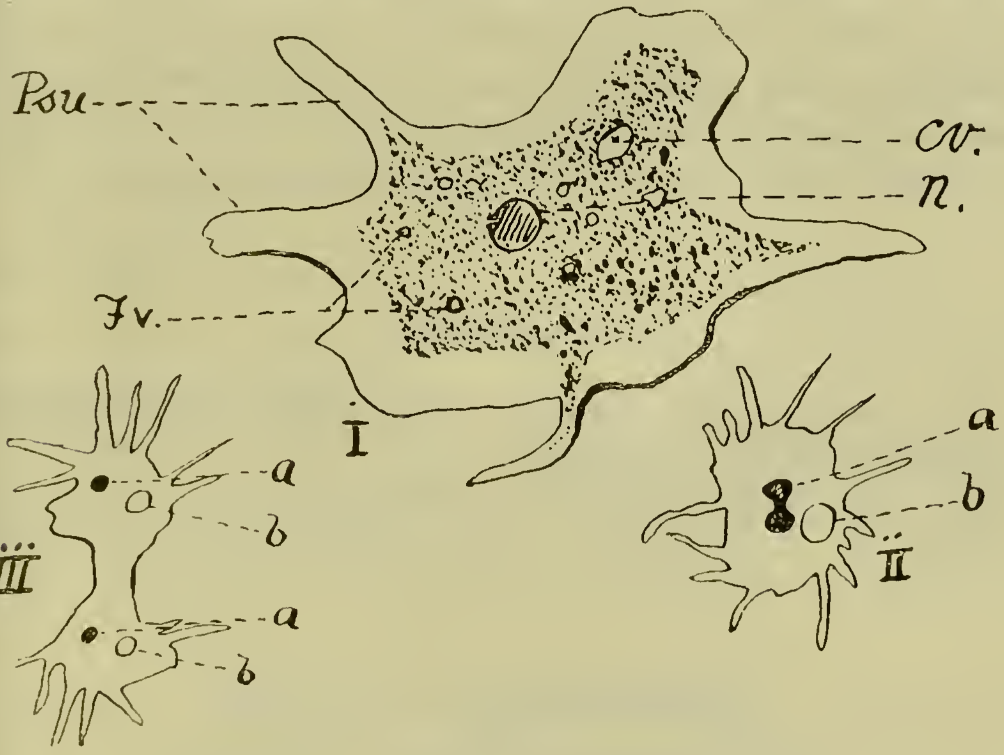

FIG. 2.—AMŒBA (greatly magnified).

i. Large specimen, showing structure. ii. A smaller specimen in process of division. iii. Later stage of ii. *a* and *n*, nucleus; *b* and *cv*, contractile vacuoles; *Fv*, food vacuoles; *Psu*, pseudopodia. (All greatly enlarged.)

This division may go on until one amœba has given rise to hundreds. But by degrees each amœba becomes smaller and smaller, and they would eventually die out. To counteract this, what is known as "rejuvenescence" takes place. Rejuvenescence is the union or conjugation of two amœbæ, whose protoplasm unites together, together with the nuclei, forming one larger individual, which is again in a fit state to undergo once more rapid division. This conjugation is really a kind of primitive sexual reproduction, although there is, as far as we can see, no difference between the conjugating individuals. At least four species of amœbæ are parasitic in man, and are spoken of as *Entamœba;* two of these are of no special account, but the *Amœba coli* (Lösch), and the *Amœba histolytica* (Schaudinn), are. The latter is the cause of tropical dysentery, and is found in man's intestines, and even the liver and kidneys. None are so far known to attack animals or plants.

RETICULOSA.

The Reticulosa are naked amœboid forms with slender, filamentous, net-like pseudopodia.

The well-known parasite of Finger-and-Toe or Clubbing belongs here.

FINGER-AND-TOE, OR CLUBBING.

(*Plasmodiophora brassicæ.* Woronin.)

This disease occurs in cruciferous plants, both wild and cultivated. It frequently causes great loss in turnips and cabbage. The roots of the attacked plants and rootlets will be found to be swollen and spindle-shaped and smooth, others as large gnarled masses. The attack commences in the young plants, from minute flagellulæ released from the countless spores in the soil entering the cells of the roots, where they become amœbulæ, and are found, often several together, in the parenchyma cells feeding on the sap. The plant-cells multiply and become abnormally swollen, and many hypertophry. Shortly the amœbulæ in each cell fuse together and become a plasmodium. Later the nuclei of the plasmodium break up into chromidia, part being destroyed, part reconcentrated to form generative nuclei. These divide by karyokinesis, and then the protoplasm collects around the nuclei to form small uninuclear bodies called gametes, which fuse in pairs. These zygotes then become surrounded by a tough wall to form round spores, which pass into the soil on the decay of the plant, and later give rise to the minute flagellulæ from which the attack originates.

The plasmodium seen in the cells is a yellowish stringy slime, which may wholly or only partially fill the cell. By October this plasmodium has broken up into spores which closely pack the swollen cells.

Prevention and Treatment.—It is very important after an attack to have as far as possible all cabbage stumps and all diseased material burnt.

Land subject to this disease should be heavily limed, the lime being in as finely divided state as possible. As it only attacks cruciferous plants, ceasing to grow them on the land for two or three years will check it materially.

CLASS II. **MASTIGOPHORA.**

These have one or more permanent organs serving for locomotion or for capture of food in the form of flagella in the adult stage. They are divided into four sub-classes: 1. Flagellata; 2. Dinoflagellata; 3. Cystoflagellata; and 4. Silicoflagellata.

The family *Trypanosomatidæ* are the most important, and they belong to a division of the Flagellata known as *Monadidea*, small protozoa of simple structure with one or more flagella. These parasites are the cause of Sleeping Sickness in man, of Nagana or Tsetse disease in stock, of Surra in horses, the Mal de caderas and the Dourine of horses. Trypanosomes (fig. 4) are specially characterised by possessing an undulating membrane. They are more or less spindle-shaped, and along one side runs the undulating membrane. Near one end of the cell is found the micronucleus or centrosome. The flagellum arises from this body and runs along the free edge of the membrane to the other end of the cell, and continues on as a free flagellum, but it may end with the termination of the undulating membrane. The true nucleus or macronucleus is placed near the middle of the body. In the genus *Trypanoplasma* (Lav. et Mesn.), the centrosome is large, and there are two flagella, one at each end of the body.

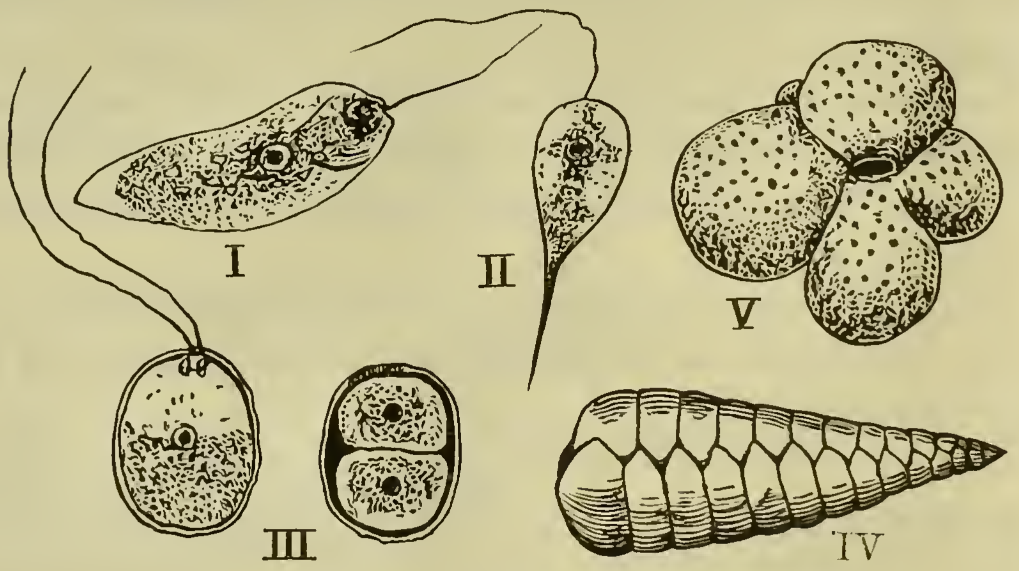

Fig. 3.—Mastigophora and Foraminifera.

i. *Euglena*. ii. *Cercomonas intestinalis*. iii. *Polytoma*, free and encysted. iv. *Textularia*. v. *Globigerina*. (Greatly enlarged.)

With but few exceptions *Trypanosoma* and *Trypanoplasma* are blood parasites, and occur free in the blood plasma, never within blood corpuscles. All the latter are blood parasites, but some of the *Trypanosomes* may be found in lymph and other serous fluids. Large numbers of these protozoa occur in the blood of mammals, birds, reptiles, fish, &c., but most are not harmful to their hosts. Some, however, are markedly pathogenetic, including the following:—

Trypanosoma brucei (Plimmer and Bradford), producing Nagana in horses and cattle in Africa;

T. equiperdum (Doplein), the cause of "Dourine" in horses;

T. evansi (Steel), the "Surra" of horses and cattle;

T. equinum (Voges), the agents of "Mal de caderas" in horses in S. America;

T. gambiense (Dutton), the parasite of Sleeping Sickness and Gambia Fever in man in Africa; and

T. cruzi (Cruz), which produces "Basilero" in man in S. America.

T. brucei occurs as a natural parasite in wild game, such as buffaloes, antelope, &c., in Africa, and does no harm to them; in S. America *T. equinum* is a natural parasite of the Capybara, but directly they get to horses and cattle their evil effects are felt. Trypanosomes have a secondary host, which is an invertebrate, which acts as an intermediary between the vertebrate hosts, with one exception—namely, *T. equiperdum*—which is said to be transmitted by means of coitus.

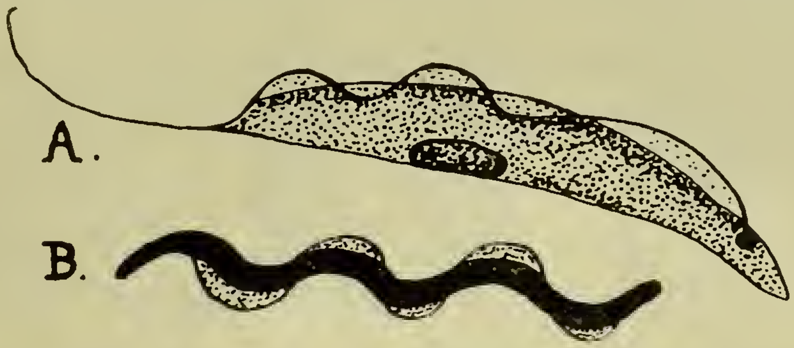

FIG. 4.—A, A *Trypanosome*. B, A *Spirochæte*. (Greatly enlarged.)

The intermediate host of these parasites of terrestrial vertebrates are blood-sucking insects, Tsetse-flies (*Glossina*), in Africa, and a Bug (*Conorhinus megistus*) is known to be the secondary host of Basilero. The secondary hosts of the parasites of aquatic vertebrates are leeches.

Reproduction is sexual and asexual, the sexually differentiated forms—*i.e.*, male and female—may, however, multiply by fission. The three types become fully differentiated only in the invertebrate host. The males are of more slender form than the females, and have a longer free flagellum. Parthenogenesis occurs in the females. The sexual forms conjugate : this may take place in the blood of the vertebrate, but it is abortive. True maturation takes place in the gut of the invertebrate host.

Spirochætæ.—These are closely related to the former, but they resemble very minute slender threads, wavy or spirally twisted in form, and have a narrow undulating membrane, but no flagella (fig. 4, B). There are several important parasites in this group : one, *S. obermeieri* (Cohn), produces human relapsing fever in Africa, and is carried by Ticks ; another, *S. gallinarum* (Marchoux and Simond), produces spirillosis in fowls in S. America. European relapsing fever is apparently carried by the Bed Bug (*Cimex*), Fowl Spirochætes especially by Ticks of the genus *Argas*.

CLASS III. **SPOROZOA.**

Another very important group of protozoa parasitic in both vertebrate and invertebrate animals is the class of Sporozoa (fig. 5). These protozoa are capable of producing serious pathological disturbances, often leading to death.

There are three orders in this class.

The order *Gregarinoidea* are only parasitic in invertebrate animals, and need no further notice.

Another order of Sporozoa are called *Coccidiidæ*, which transform themselves into egg-shaped zoosperms by the formation of a capsule and the production of several large spores from their granular contents.

The third order are the *Hæmosporidea.*

Disease-producing Sporozoa.—Four well-known maladies are produced in birds, animals, and man by these low forms of life —namely, *coccidiosis*, or "liver-rot," in the rabbit ; *psorosper-*

mosis of the skin in many animals, and especially birds—the so-called "canker" of pigeons; *piroplasmosis* in cattle, dogs, &c., such as Redwater and East Coast fever in cattle; and malignant Jaundice in dogs; and the Malarial fever of man.

THE COCCIDIIDEA.

These are parasitic in the epithelial cells, and always with distinct alternation of generations—namely, endogenous non-sexual schizogony and exogenous sexual sporogony. The epithelium most usually attacked is that of the gut and the liver.

Coccidiosis is a common complaint affecting the liver of the rabbit, and is produced by the species known as *Coccidium oviforme* (fig. 5). This sporozoan is ovoid when adult, and enclosed in a double-contoured shell from 30μ to 50μ long and from 20μ to 28μ broad. These extremely minute bodies become

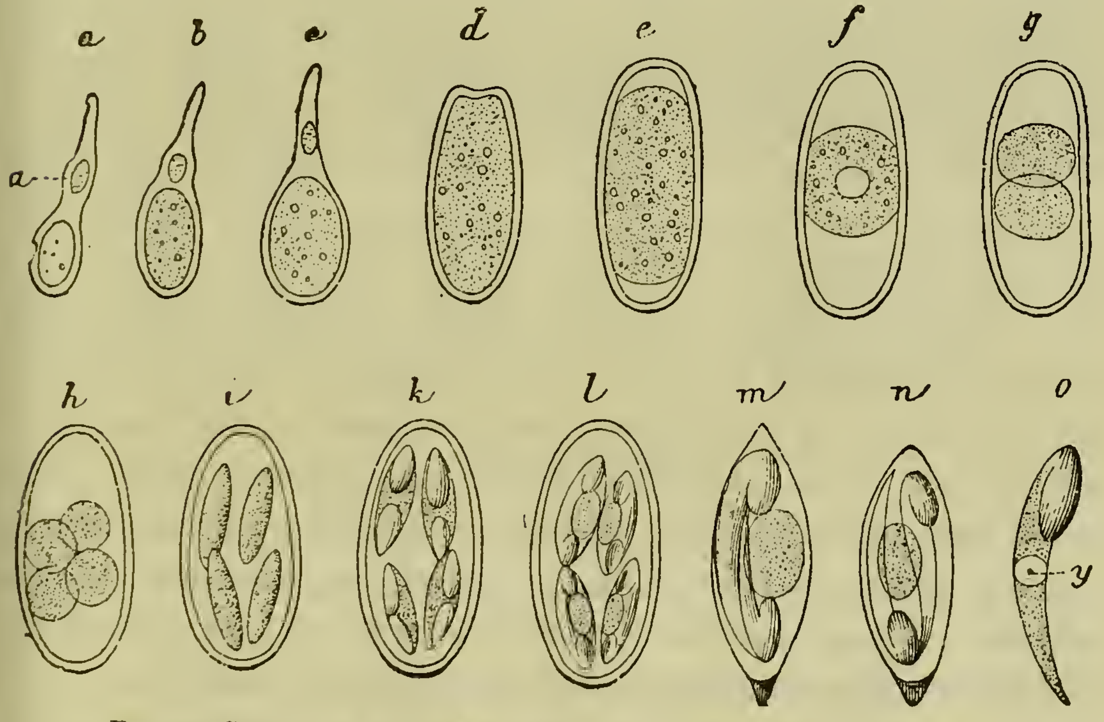

FIG. 5.—COCCIDIUM OVIFORME OF RABBIT'S LIVER. After Balbiani.

a, *b*, *c*, Young Coccidia in epithelium of liver; *d*, *e*, *f*, encysted adult Coccidia; *g*-*l*, development of sporoblasts; *m*, mature sporoblast, showing the two falciform bodies; *n*, the two spores separate; *o*, a falciform spore—*y*, its nucleus. (From Par. Dis. Ani., Neumann.)

encysted, when we observe that their protoplasmic contents separate away from the cell-wall and form a central round or oval mass (*f*). Both adult and encysted stages may be freely detected in the liver, in the white and yellow patches which are characteristic of the disease. Now if we collect numbers of these encysted forms and place them on damp sand in a warm temperature, we shall soon observe by microscopic examination that the central protoplasmic ball splits into two and then four (*g* and *h*). This is a kind of segmentation or division, the round bodies being known as "sporoblasts." These sporoblasts elongate, expand at each end, and are seen to be surrounded by a thin membrane, within which is also seen a granular lump. Each of these "sporoblasts" really contains two spores, the falciform spores (*o*), described in a typical sporozoon—in fact, the so-called sporoblast is a pseudo-navicella. Each falciform body gives rise to a little flagelloid creature. This form migrates from cell to cell of the animal's liver, encysting and producing more spores, and so rapidly increasing the area of the disease. It is supposed that these sporiferous cysts are carried with dust, &c., and hence get taken into the mouth with food, eventually reaching the liver. The sporocyst ruptures through the action of the pancreatic juice, the gastric juice having no effect upon them, and the sporoblasts appear; these latter burst and discharge the spores or falciform bodies, which become active, and are said to ascend by the ductus choledochus to the epithelium of the liver and bile-duct. Here the germs, having entered some of the hepatic cells, cause these cells to rupture, and they may even destroy the walls of the bile-duct itself. They finally encyst, pass out into the intestine, freed by the breaking up of the tissues in which they are embedded, and so out to ground by the anus of the diseased animal.

Their presence causes the liver to swell. They are detected by the creamy cystic areas, varying in size from a millet-seed to that of a pea. They are often so abundant that the cells of the liver atrophy, and cheesy-like masses appear not only in the liver substance but in the bile. These prurigerous masses on microscopic examination are found to contain numbers of coccidia. It may possibly be taken for tuberculosis unless carefully examined. The walls of the intestine may be invaded as well as the liver.

HÆMOSPORIDIA.

These protozoa have an alternation of generations corresponding with an alternation of hosts: the non-sexual stage is passed in the blood of a vertebrate, the sexual sporogonous stage in the gut of an invertebrate. They are all parasites of the blood of animals and man, and have risen into great prominence from the fact that they are the cause of malarial fevers in man and the devastating cattle diseases, such as East Coast fever, redwater or Texas fever, and the fatal malignant jaundice of canines.

The malarial fevers are carried by several species of mosquitoes belonging to the Anophelinæ, the cattle and canine fevers by Ticks.

Only two genera of Hæmosporidia need be mentioned here—namely, *Plasmodium*, which contains the malarial species, and *Piroplasma*, which contains the animal fever parasites.

PIROPLASMOSIS.

This latter genus contains several species parasitic in the blood of mammals (fig. 6). These species are so closely related that they can scarcely be distinguished from one another, save for the fact that they occur in different hosts. The diseases these blood parasites produce are spoken of as *piroplasmoses*. In acute form the chief symptom is hæmoglobinuria, caused by the destruction of the red blood corpuscles.

Redwater.—This is one of the best-known diseases caused by *Piroplasmæ.* It is also spoken of as Texas or Southern fever in America. This is caused by the parasite *Piroplasma bigemina* (Smith and Kilborne). The species producing European Redwater is the same. The parasites occur during one period as pear-shaped bodies in the blood corpuscles, 1·3 to 1·5 μ in length, and in this species two occur in each corpuscle. They may appear as rod-shaped bodies. Free forms also occur in the blood and sometimes a flagellate form. They increase in the blood corpuscles by binary fission. Animals with these parasites may be immune, but their blood injected into other animals will cause the disease. Relapses also take place. The intermediate hosts of this disease are the Ticks (*Ixodes ricinus*) and (*Rhipocephalus* (*Boophilus*) *annulatus*). The malignant jaundice in dogs is caused by *Piroplasma canis*, the East Coast fever by *P. parvum*, another is found in the horse, *P. equi*—all these have intermediate Tick hosts (*vide* Ticks). For information concerning other forms, such as *P. parvum* (Theiler), the parasite of East Coast or Rhodesian fever, the *P. canis*, causing malignant jaundice in dogs, and *P. equi* in horses, the student is referred to Professor Minchin's recent work on Protozoa.[1]

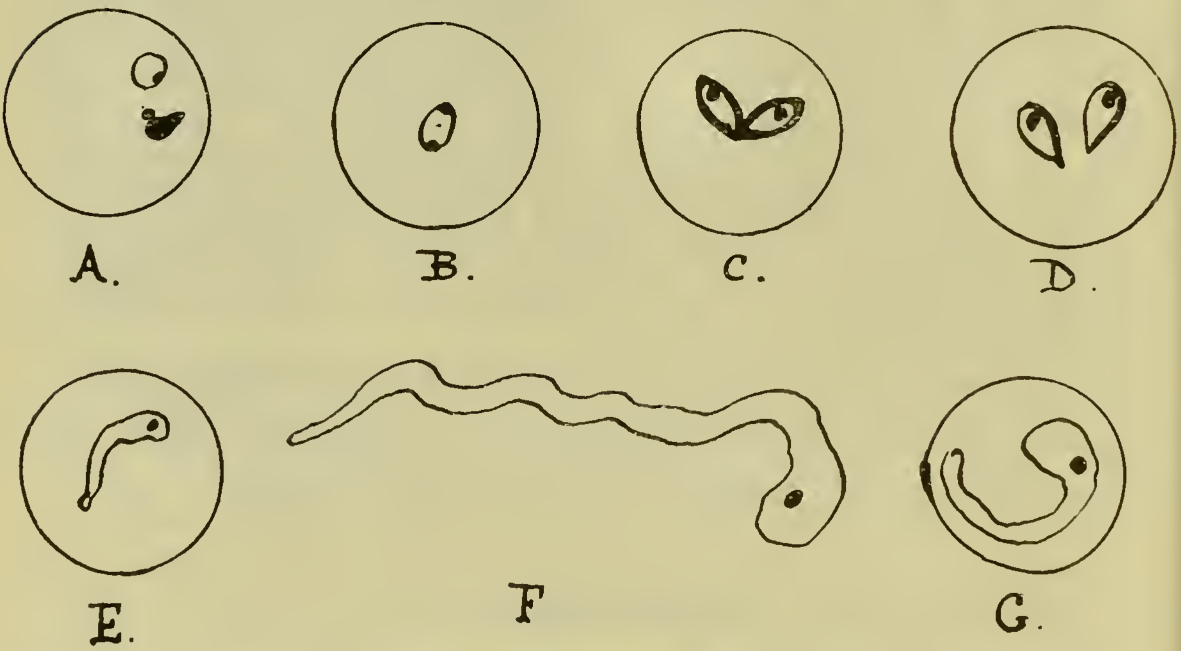

FIG. 6.—PIROPLASMÆ.

A to D, *Piroplasma bigemina*. Ring forms A B; pear-shaped forms C and D. E and G, *Piroplasma canis* in blood corpuscles. F, Parasite free in blood. (Greatly enlarged.)

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[1] An Introduction to the Study of the Protozoa. By E. A. Minchin, M.A. 1912.

MALARIA.

The malarial fevers, our old Fen ague, are produced by species of *Plasmodium* (Marchiafara and Celli); other species also occur in mammals and birds. In all cases the agents of transmission are mosquitoes or Culicidæ; in the human malaria only Anopheline Culicidæ can carry the parasites. There are three species (1) of Tertian fever (*P. vivax*), (2) the quartan parasite (*P. malariæ*), and (3) the pernicious or tropical species (*P. immaculatum*). One marked character of these is that they produce a black substance called Melanin. The parasites are injected into man's blood by the Anopheline mosquito, and then enter the red corpuscles, feed, grow, break up into spores, and destroy the corpuscles; the spores enter other blood corpuscles, and so the fever is set up. The Anopheline, whilst taking man's blood, injects the parasites with the saliva, and the insect at the same time obtains other forms from the blood, and a male and female stage is formed in the insect. The male throws off portions which conjugate with or fertilise the female parasite, which then wanders into the walls of the stomach and later, on the outer wall, grows to a great size and eventually breaks up into a large number of elongated spores, which enter the salivary glands of the mosquito. In man, therefore, we get asexual spore-formation (schizogony), in the mosquito sexual generation ending in sporogony.

CLASS IV. **INFUSORIA.**

The Infusoria are Protozoa which are provided with cilia for locomotory purposes. They have also a vegetative macronucleus and a generative micronucleus.

At one time the Flagellata were included in this class.

There are two sub-classes—(1) *Ciliata* and (2) *Suctoria*.

In the first the cilia occur during the whole active life of the adult, but are not found when they are encysted. In the second, cilia are only present during the larval stage, their place being taken by suckers and tentacles. None of the latter are parasites on metazoa. The Ciliata are the most complex of the Protozoa, and several occur as parasites in metazoa. In form they are typically ovoid, one pole being directed forwards in swimming, whilst in creeping species the body is flattened; others, as the Bell Animalcule (*Vorticella*), are fixed by a stalk. They are of definite form, the body being enclosed by a cuticle. In this cuticle is an opening, the *cystotome* or mouth, and there may be a definite anus or *cytopyge.* The mouth is merely a pore passing through the ectoplasm.

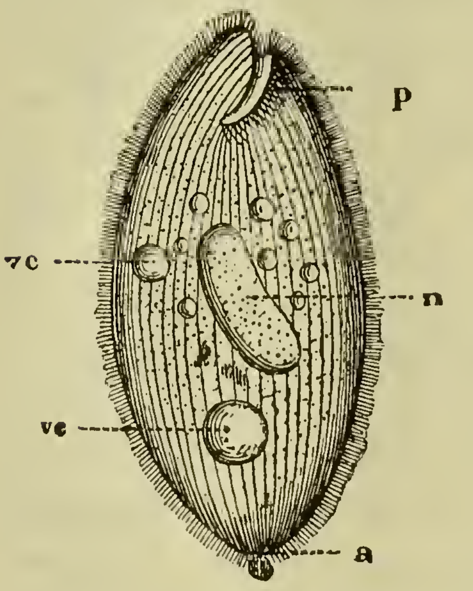

FIG. 7.—CILIATE PROTOZOAN (*Balantidum coli*).

a, pseudo-anus; *n*, nucleus; *vc*, contractile vacuoles; *p*, peristome (Stein). From Par. Dis. Ani., Neumann.)

Ciliata reproduce by fission or budding (gemmation), and also when encysted by sporulation.

Parasitic forms encyst when out of their host, and then can remain dormant until taken up by another host.

Those that are parasitic occur in the digestive tract and other internal cavities, but never as tissue parasites. There are four orders—(1) *Holotricha*, in which the cilia are of even length and spread all over the body; (2) the *Heterotricha*, in which a special adoral zone of larger cilia is always present; (3) *Hypotricha*, which are creeping forms and flattened (not parasitic); and (4) *Peritricha*, which are fixed forms like Vorticella, without locomotar cilia.

Balantidum coli (fig. 7) is one of the Heterotricha. It is found in the rectum, &c., of pigs and man. These white ciliata are found as free-swimming bodies in the rectal matter.

They pass out on the dung and encyst. When food becomes soiled by excrement they are taken into the alimentary canal. Another species, *B. minutum*, has also been recorded in man.

Enough has been said of this group of simple animals, the most rudimentary forms of animal life that exist, to show that they *are* of some considerable importance, not only to the farmer and poultryman but to man in general, and that a knowledge of their habits and life-histories is not only of interest but of very great economic value to us.

CHAPTER III.

SPONGES, CŒLENTERATES, AND ECHINODERMS.

Spongidæ or Porifera.

A sponge is a compound structure of true animal nature. It is composed of contractile tissue, which is supported by a skeleton of hard spicules or fibres. In past ages sponges were thought to be plants, but their true animal nature has long since been demonstrated. The simplest form of sponge is represented by a fixed cylindrical tube, with an exhalant opening, called the *osculum*, at the free end. The contractile wall of the cylinder is supported by rayed spicules, which may be calcareous or siliceous and of very variable form : it is perforated by small pores, known as inhalant pores, which lead into ciliated internal chambers. In these ciliated chambers are found cells lining the cavities peculiar to the Sponge. Such cells are called "collar cells," each being provided with a long cilium and a distinct nucleus in the lower part of the cell. The reproduction of sponges is much more advanced than in the Protozoa. True ova are found in the layer of tissue known as the mesoderm, or middle layer. These ova go through a process of cell-division known as *segmentation*, a process henceforth to be observed in all the following groups of animals. The single cell, the ovum, at first divides into two, but, unlike the protozoan, it does not separate ; then by further division four cells are produced, then eight, then sixteen, then thirty-two ! Eventually there is formed a free-swimming body, a larva, which is composed of a number of cells ciliated on the exterior. This larva is called an *amphiblastula*, which, after leading a free aquatic life, eventually settles down, and, fixing on to a stone on the floor of the sea, becomes gradually metamorphosed into a sponge. Most sponges are marine; a few, however, are fresh-water—one common form, *Spongilla fluviatilis*, being often abundant in our streams.

CŒLENTERATES.

Cœlenterates include the Jellyfish, Sea-anemones, and Corals. These marine animals have regular consistent tissues. The cells of which they are built up have lost their original form, and have become sorted out into different groups, each with their special functions, the various groups forming the tissues of which the animals are built up. In the outer layer of cells (the skin or epithelium) there are found in all Cœlenterates, more or less highly developed, certain cells that are known as "thread-cells"—cells that are modified as weapons of offence and defence, being endowed with stinging propensities. Each of these cells, or "cnidoblasts," is provided with an internal barbed thread. When the cell is touched, this thread, like a flagellum of one of the Protozoa, is darted out and enters the skin of the prey or enemy, carrying with it a certain amount of poison, which produces the curious stinging and even paralysing sensation we experience when a jellyfish settles upon us when we are swimming in the sea. The amœboid cell-unit here loses its individuality. Amongst these Cœlenterates we find two chief types, the so-called *Medusa* or Jellyfish and the *Polyp*. These two totally different animals are one and the same, the medusa being a sexual form of the asexual polyp. There is thus produced a most remarkable phenomenon, known as the *alternation of generations*—that is, the alternation of a sexual and an asexual form of the same creature.

The class Cœlenterata contains the Corals (*Actinozoa*), Dead-men's Fingers (*Octactinia*), Sea-anemones (*Hexactinia*), the polypoid and medusoid *Hydrozoa*, and the *Ctenophora*. A polyp is a simple tubular body fixed at the posterior end and pierced by an oral opening at the free end, the mouth being surrounded by a circle or several circles of tentacles. Polyps may reproduce by male and female cells—spermatozoa and ova—or by budding. All colonial forms are produced by the latter process. A medusa or jellyfish is free-swimming, and consists of a flattened or arched gelatinous disc, that we so often see floating on the top of the sea. From underneath this disc there hangs down a stalk, the manubrium, at the free end of which opens the mouth. Tentacles may be developed around the mouth and edge of the disc. Here in the medusa we find that the distinctly defined mouth leads into a canal that runs up the stalk and enters a cavity in the disc, the stomach, from which canals run out to the edge of the disc, where they form a circular canal surrounding it.

A medusa may be compared to a flattened polyp. In the hydroid polyp stock reproduction takes place by budding, so that the individual colony increases; but every now and then a modified bud forms—a medusoid bud—in the place of a polyp. This bud breaks off and floats away as a medusa, which becomes sexually mature, producing ova: these ova hatch into free-swimming larvæ that settle upon some rock or stone, when each larva turns to a polyp which creates a colony by repeated gemmation. Thus we get an alternation of a fixed asexual and a free sexual generation.

ECHINODERMS.

Starfish, Sea-urchins, and Sea-cucumbers are united into one class known as the *Echinodermata*. All these animals are marine. They are characterised by their radial symmetry. They have generally a hard calcareous exoskeleton, which may bear calcareous spines. Within the tests are placed the fully developed alimentary canal, and the water-vascular and reproductive organs. The starfish, &c., reproduce sexually. The ova produced give rise to curious larval forms, quite unlike the adult.

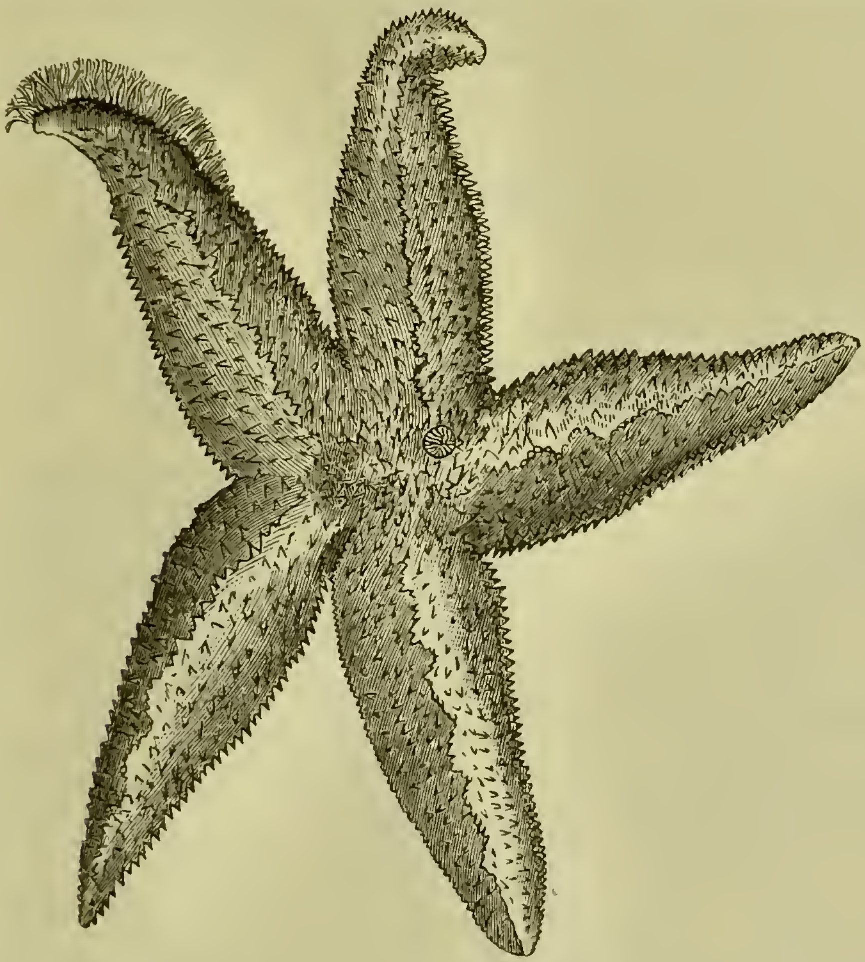

FIG. 8.—THE COMMON STARFISH (*Uraster rubens*). From Nicholson.

The group must be summarily dismissed here, as they are of no importance to the agriculturist, except in the case of the starfish (fig. 8), which are sometimes employed as manure, the so-called "five-finger" manure, in neighbourhoods near the coast.

CHAPTER IV.

WORMS.

PLATYHELMINTHES OR FLAT-WORMS.

WORMS are most variable in form, habits, and structure. They are of great interest, owing to their often complex life-histories. To man and his animals they are often deadly enemies, giving rise to such serious and often fatal diseases as *Filariasis*, *Trichinosis*, Miner's Disease, *Strongylosis*, and *Tæniosis*. Nearly every animal harbours one or more vermiceous guests. Some seem to occasion little or no inconvenience to their host, whilst others, if not fatal, are most annoying. Some live as parasites in the blood (*Hæmatozoa*), others in the alimentary canal (Tapeworms), others in the liver (Flukes), and even in the eye (*Filaria oculis*). There are also worms, such as the earthworms, that are of the greatest service to man, helping to fertilise the soil. Worms may be found in a great variety of places. Large numbers are marine; others live in fresh water; yet others upon land, in damp earth, moss, and in excreta. It is, however, those that lead a parasitic existence, living in some other animal or plant, that we shall have to consider most fully.

Worms are bilateral animals with unsegmented or segmented bodies. They never possess any jointed lateral appendages, such as we shall see in the group (*Anthropoda*) that includes the insects and spiders. A dermal muscular system is developed, and there are present paired excretory tubes or canals.

The bodies of worms are typically elongated, cylindrical, and soft, adapted to live in damp media. We can always distinguish a dorsal or upper and a ventral or lower surface. Some worms are flat, and are known as *Platyhelminthes;* others are round, and are called *Nemathelminthes:* these round worms are never segmented. A third group are round or nearly so, and are more or less segmented; these are known as *Chætopoda* and *Hirudinea.*

In the more highly developed worms the two anterior segments unite to form a head. The skin is very variable, and covers a strong muscular layer or coat. The cuticle, or outer layer of the skin, may become very thick, and then forms a kind of exoskeleton. The layers under the skin, the true *cutis*, contain circular and longitudinal muscle-fibres: these produce a thick layer, and enable the worms to move with great power by their muscular contractions. The internal organisation of this class of invertebrates is also very variable. In such worms as are parasitic and live on the juices of other animals, the alimentary or digestive canal may be absent (*Cestodes*). Nutrition then takes place much as in plants—namely, by the process of *endosmosis;* the nutritive fluids are absorbed through the skin. When an alimentary canal is present we find that the mouth is always ventral, and that there may (*Nematoda*) or may not (*Trematoda*) be a posterior exit, the anus. The mouth generally gives rise to a muscular pharynx, which opens into a well-developed stomach, followed by an intestine of very variable length and structure, a short rectum uniting the latter with the anus.

In the worms we find a well-developed *nervous system.* In the most simple form seen in these invertebrates there is only a single or paired mass of nerve-cells, the so-called ganglia, over the gullet or œsophagus. These ganglia are called the "brain," and from them proceed nerve-fibres, some going anteriorly to the sense organs, others posteriorly to the skin, &c. In Chætopods, arising from the ventral or sub-œsophageal ganglion, are two nerve-strands: these in each segment of the worm swell out into two ganglia, which are united by connecting nervous matter called commissures. This chain of ganglia and the nerves attached form the ventral *nerve-cord.*

Eyes, auditory organs, and tactile organs are sometimes united to the nervous system, forming primitive *sense organs.*

A *vascular system* is present in some groups, such as the *Chætopoda*, *Nemertinea*, and *Hirudinea.* The blood is generally yellow or green, sometimes quite clear, and occasionally red. It is red in the earth-worm, in which the vascular or blood system is best studied. It consists of dorsal and ventral blood-vessels united by lateral vessels, and it is also provided with paired swollen trunks called "pulsating" or "blood hearts." Worms respire through the whole body surface, except in some marine *Chætopoda*, which have specially modified branched gills found at the base of the limbs. *Excretory organs* are also present, consisting of paired canals called "nephridia," which may open by a single pore (*Nematoda*). In the segmented worms, like the earth-worm, these nephridia are paired in each segment. The nephridia, which are the equivalent of the kidneys in the higher animals, open into the interior or body cavity of the worm by a ciliated funnel, and to the exterior by a small pore on each side of the segment.

Both sexual and asexual *reproduction* take place in worms—asexually, by fission and gemmation, amongst the lower forms. In many cases both male and female organs are found in the same individual, when it is known as an *hermaphrodite.* This we can readily observe in the earth-worm. Many others (most of the Nematoda) have the sexes in separate individuals, the male being, as a rule, much smaller than the female. Both direct and indirect development take place. Many species pass through a metamorphosis, the egg giving rise to a larval form, which by a series of changes assumes the adult condition. In the parasitic species two hosts are often requisite for development, and in these parasitic forms the embryonic stage is sometimes capable of asexual reproduction, when the metamorphosis assumes a complicated alternation of asexual and sexual generations. The *Trematodes* or Liver-flukes, and the *Cestodes* or Tapeworms, have this phenomenon in their life-cycle.

The worms are divided into several classes. The four most important here are:—

(i) *Platyhelminthes.* (ii) *Nemathelminthes.*
(iii) *Chætopoda.* (iv) *Hirudinea.*

(i) The **Platyhelminthes** are Flat-worms with elongated bodies and cerebral ganglia; they are provided with suckers and hooks. Most are hermaphrodites. They are grouped in five orders:—

(*a*) *Turbellaria* (Planarians, &c.) These are of no agricultural importance.
(*b*) *Trematoda* (Flukes). Parasitic, and produce various diseases in animals.
(*c*) *Cestoda* (Tapeworms). Purely parasitic, in man, animals, and birds, often with complicated life-history.
(*d*) *Nemertinea.* Parasitic only in Mollusca and Crustacea.
(*e*) *Mesozoa.*

(ii) The **Nemathelminthes** are Round-worms, with tubular, cylindrical, or filiform bodies. The anterior or head region is either armed with hooks or papillæ, and there may be hooks on the posterior end of the male. Sexes separated. There are three sub-classes:—

(*a*) *Nematoda* (Thread-worms). Many of these round thread-worms are most injurious to animals, birds, and man, living as parasites in various parts of the body.
(*b*) *Acanthocephala*, a small group of Nemathelminthes found parasitic in man and some animals.
(*c*) *Nematophora*, which are partially parasitic in insects.

(iii) The **Chætopoda** are segmented worms with a so-called "brain," an œsophageal nerve-ring and a ventral nerve-cord, and a closed vascular or blood system. They form the highest group of worms, and are, as a rule, free living; some are partially parasitic. There are three sub-classes:—

(*a*) *Polychætæ.* Marine worms only.
(*b*) *Oligochætæ.* Earth-worms, &c.
(*c*) *Myzostomaria.*

(iv) **Hirudinea** (Leeches). These are partially parasitic; they have no parapodia, and are armed with a ventral terminal sucker for attachment, and also with an oral sucker. They are hermaphrodites, like the Earth-worms.

The worms for us to consider—that is, those having a bearing on agriculture and horticulture—are the *Trematodes* or Liver-flukes, the *Cestodes* or Tapeworms and cysts, the *Nematoda* or Thread and Whip worms, and the allied *Acanthocephalæ*, the *Oligochætæ* or Earth-worms, and the ecto-parasitic *Hirudinea* or Leeches.

PLATYHELMINTHES OR FLAT-WORMS.

The Flat-worms are mostly parasitic, such as the Flukes and Tapeworms. They may or may not be segmented, and are usually hermaphrodites. Their bodies are flattened dorso-ventrally; in very few is an anus present. Two hosts are generally necessary to complete their life-cycle, and the sexual form may attain a great size. Both sexual and asexual reproduction take place, the development often being accompanied by a complicated alternation of generations. The parasitic species are all provided with suckers, and most of them with hooks for attachment to their host. They are mostly oviparous.

The Trematoda or Flukes.

The Flukes or Trematodes are parasitic worms with unsegmented, usually leaf-shaped, flat bodies, resembling somewhat a "Flat-fish" in form. They possess a mouth surrounded by an oral sucker, and also a ventral sucker, but no anus. Most

Trematode worms go through a kind of alternation of generations, and live in two distinct hosts during their changes.

We can distinguish two groups of Flukes—(1) the *Distomata*, which have two suckers and no hooks, and present an alternation of sexual and asexual generations,—the asexual phase always taking place in some mollusc. (2) The *Polystomata*,[1] which have two small lateral anterior suckers and one or two posterior suckers. Hooks, usually two in number, are also present. There is no alternation of generations, they live outside or upon their host (ecto-parasites) instead of internally (endo-parasitica or entozoa), as is the case in the Distomata.

Structure of a Trematode.—A typical fluke, such as the Sheep-fluke (*Distomum hepaticum*),[2] has a bifurcated alimentary canal with simple or ramifying branches, and terminates in a *cul de sac;* there is thus no anus. The excretory apparatus consists of a network of fine tubes which converge into canals; these become gradually larger, and end in one or several longitudinal vessels, which finally culminate in a dilated pulsating vesicle that opens to the outside by a pore, the caudal foramen. The *Distomum* are hermaphrodites. The male organs are two tubular testes, that unite into a "cirrus" or penis, which is surrounded by a sheath. The female organs consist of an ovary and oviducts. Attached to the ovary are two glands known as the "albuminous glands," which secrete a granular fluid. There is also a shell-gland, uterus, and vagina, which open by the vulva close to the male organ. The ova of the fluke are found in the uterus, where they undergo the first stage of development—namely segmentation. Another important species, *Bilharzia hæmatobia*, has a male and female form. A nervous system is developed, consisting of two sub-œsophageal ganglia united by a transverse commissure, and a single sub-œsophageal ganglion joined to the others by two lateral commissures, and a few nerve-filaments.

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[1] These are now spoken of as (i) *Digenea*, and (ii) *Monogenea.*

[2] This is often called *Fasciola hepatica.*

Trematodes are found in the intestine, biliary canals, bladder, respiratory apparatus, and in the sub-orbital sinus of birds. One of the most important is the Liver-fluke (*Distomum hepaticum*), which produces the "liver-rot" in sheep or the so-called *distomatosis.* Another species, also found in the liver region of the sheep, is *D. lanceolatum*, a smaller and more pointed species.

The **Liver-fluke** (*D. hepaticum*) (fig. 9).—The body of this destructive fluke is leaf-like, flattened, and of an irregular pale-brown colour. It is about an inch in length and half an inch across at the widest part; it is oval and lanceolate in shape, broader and rounder in front, where it suddenly contracts to form a kind of neck. The cuticle is studded with numerous small prickles, directed backwards, which one can easily feel on pulling the worm through the fingers from tail to head. The oral sucker is terminal, small, and round; the ventral sucker is towards the anterior end, large and round, with a triangular depression. The intestine can be seen through the integument as two dark forked branches. The ova, which may often be seen in the uterus, are ovoid bodies of a dark-brown colour.

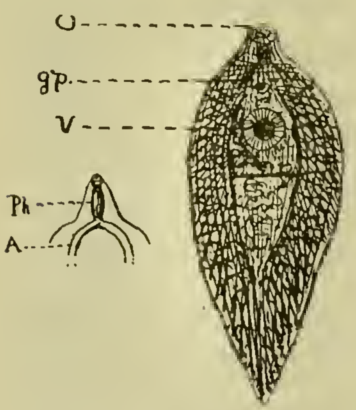

FIG. 9.—LIVER-FLUKE (*Distomum hepaticum*).

o, Oral sucker; *gp*, genital pore; *v*, ventral sucker; *ph*, pharynx; *a*, alimentary canal.

Lambs are especially affected. The same species is found in goats, cattle, camels, the horse, pig, rabbit, and man. They live chiefly in the biliary ducts of the liver. Damp wet seasons and damp ground favour the spread of distomatosis. Fields liable to be flooded along the course of rivers are often certain to cause sheep to be infested with Fluke, the cysts being spread over the grass when the floods are out, and afterwards taken in by the lambs.

Life-history.—The life-history of this species has been determined by Leuckart and Thomas. The ova pass out from the bile-ducts through the intestine to the ground in the excreta. Each ovum is provided with a lid, which breaks off, and the embryo is released. Incubation takes place in the summer, and occupies from three to six weeks. The embryo is covered with fine hairs—cilia—and is known as the *ciliated embryo* (fig. 10, A). It is lanceolate in form, broadened in front, and provided with a curious boring apparatus at the anterior end. It is necessary that this embryo should meet with its first host within twenty-four to thirty hours after it has hatched. Should it not do so it dies. Its first host is one of the water-snails (*Limnæus*) that we see in such abundance along the sides of streams, runnels, and dykes. If the embryo comes in contact with one of the Limnæi, it bores its way into its body by means of the anterior process, and then enters the respiratory cavity. The host in this country is *Limnæus truncatulus* (fig. 173, A); in S. America it is *L. viator;* in the Sandwich Islands, *L. peregra.* On arriving at the respiratory cavity of this snail the embryo encysts, and becomes converted into a body known as the *sporocyst* (fig. 10, B).

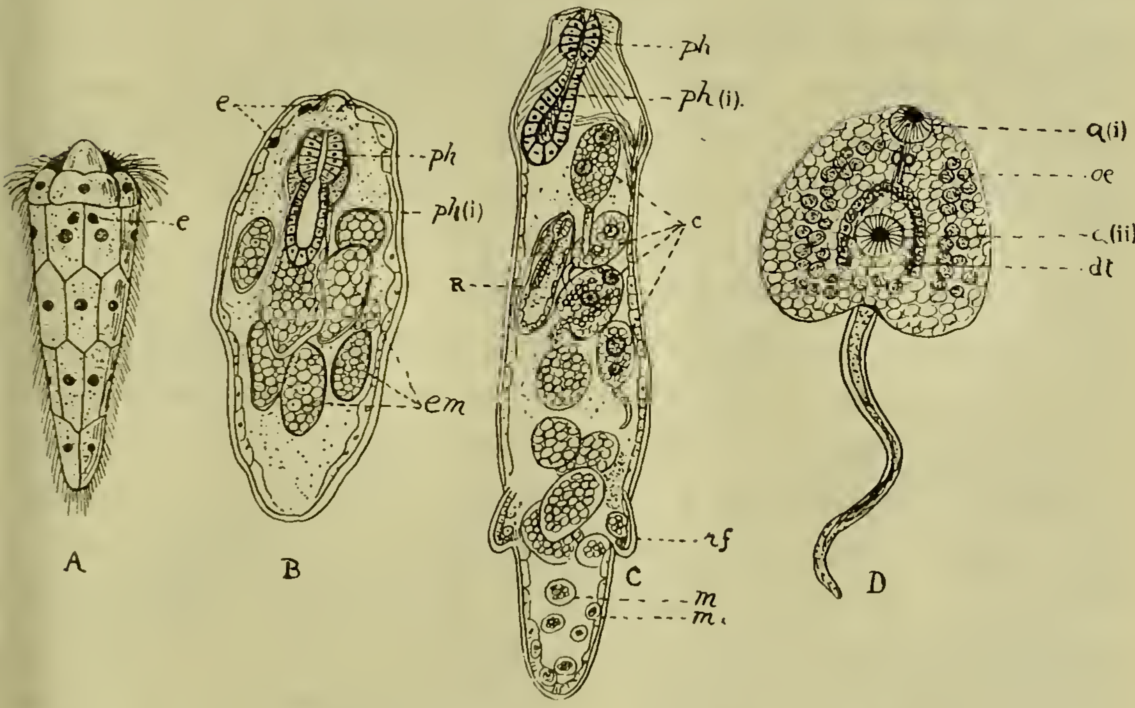

FIG. 10.—LIFE-HISTORY OF DISTOMUM HEPATICUM.

A, Ciliated embryo. B, Sporocyst. C, Redia. D, Cercaria.
e, Pigment spots; *ph*, pharynx; *ph*(i), blind-gut; *c*, cercariæ; *m*, germinal cells; *em*, young redia; *rf*, lateral "fins"; *a*(i), anterior sucker of cercaria; *a*(ii), ventral sucker; *œ*, œsophagus: *dt*, blind-gut. (After Leuckart and Thomas.)

The sporocyst is an oval body with neither mouth nor anus. Its contents split up into a number of bodies, usually varying from six to eight. These structures, found inside the sporocyst, have been formed asexually by internal gemmation, and are known as *Rediæ* (*em*). Each redia (C) is about $\frac{1}{12}$th of an inch in length. Later the sporocyst bursts and the rediæ are released, passing out of the rupture one by one. The rediæ (C) still remain in the snail, where they move about in the mantle cavity. They, unlike the sporocyst, are provided with an alimentary canal and mouth (*ph*). Again asexual reproduction comes into play, for each redia gives rise by budding (internal) to a number of tailed creatures, known as *Cercariæ* (*c*). About fifteen to twenty cercariæ are produced from each redia. These little tadpole-like organisms pass out of an unpaired orifice near the neck of the redia and swim out of the snail, leading a free life in the water for a short time. These free forms (D) resemble the adult fluke, only they are much smaller, and are provided with a long tail. Eventually the cercaria anchors itself on to a blade of grass or some water-weed, draws in its tail, and becomes converted into a round cyst. Here this agamous cyst will remain until some sheep comes along and devours it with the grass. On being transferred to the stomach of the sheep or lamb the case of the cyst is dissolved, and the young or immature fluke is released. It then passes into the duodenum, finally entering the liver, where it grows and produces countless numbers of eggs.

The diagram (fig. 11) shows perhaps more clearly the life-history of this all-important pest.

This parasite occurs over all Europe, Northern Asia, North Africa and Abyssinia, the Canaries, the Faroes, and also in Australia, the Sandwich Islands, and S. America.

The *symptoms of the disease* caused by this worm may be noticed in four periods. The first is the period of immigration, when the embryos invade the liver: little or no change is then noticeable in the host. The second is a period of anæmia: this usually commences thirteen weeks after infection, and during the months of November and December. Rapid fattening of the diseased sheep, fever, and quickening of breath are common symptoms at this stage. Death may now result from apoplexy. The third period is marked by a rapid loss of flesh,

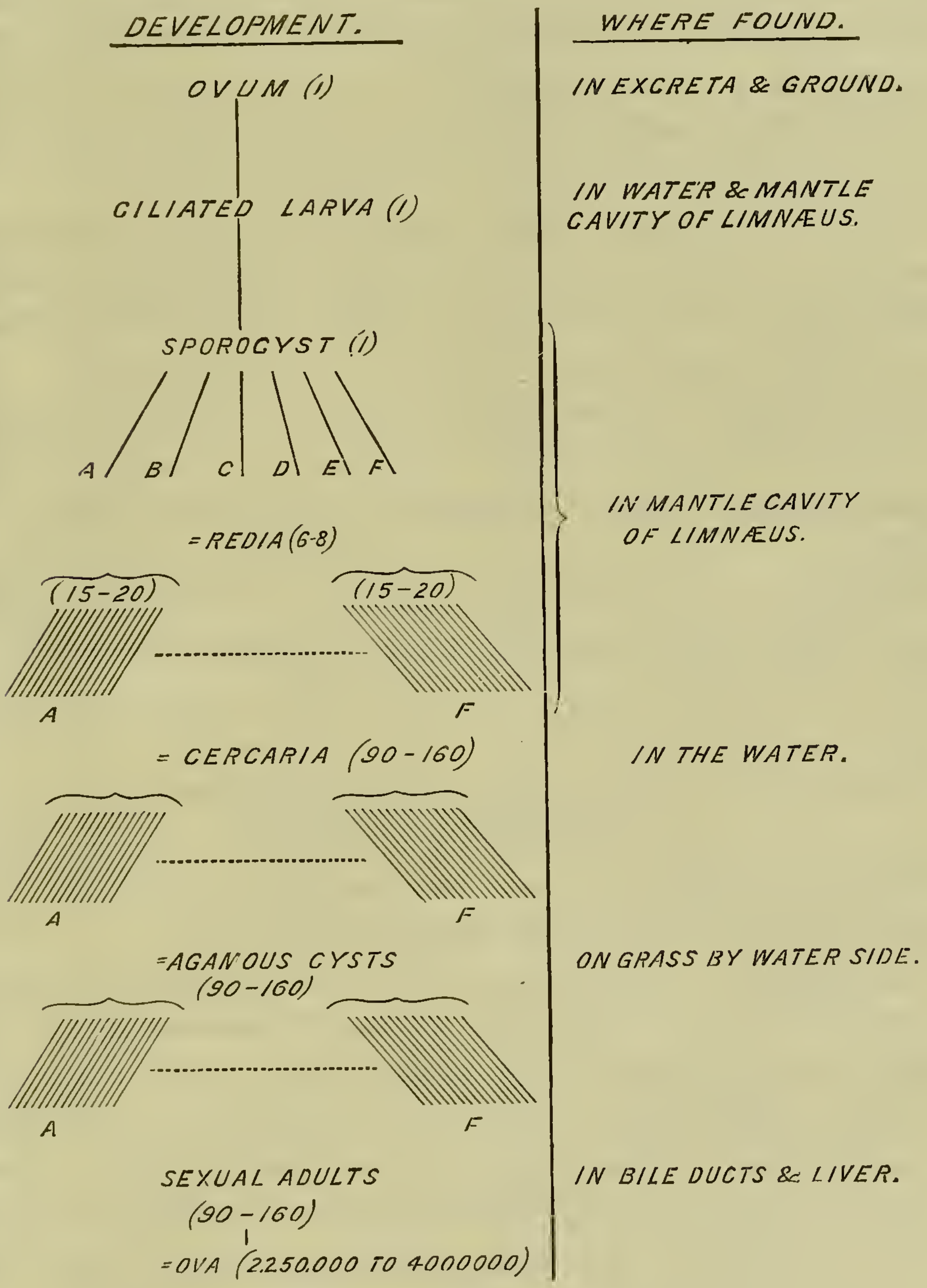

Fig. 11.—Diagram showing Life-history of Liver-fluke.

which usually manifests itself about January. Diarrhœa and jaundice occur now, and either death ensues or there is a spontaneous recovery. The last period is that of the emigration, when the flukes are all mature and all the ova have been passed out, the sheep then recovering.

Generally, according to Neumann, flukes remain in their host from nine to fifteen months.

Effects on the liver.—When invaded the liver becomes thick and soft, and the surface is rough instead of smooth. Inflammation sets in, and a dark serous fluid is found in the abdomen. The biliary canals become thickened and much enlarged. The liver eventually becomes soft and friable. Flukes are of course to be found in the diseased organs in numbers, the writer having taken as many as seventy from one lamb's liver and bile-duct.

Liver-rot occurs worst in certain years. In Britain in 1816, 1817, 1830, 1853, and 1854 it was particularly bad, all wet years. In 1830 England lost one and a half million sheep from this pest, representing four millions of money. In 1879-80 three million died. In 1862 Ireland lost 60 per cent of the sheep, and in 1882 millions died in Buenos Ayres. Recently the disease has been on the decline in Britain. This Fluke occurs in many other animals, and man.

Lung-flukes.—Sometimes flukes are found in the lungs of sheep and oxen. These lung-flukes (*D. pulmonale*) are contained in cysts, usually in the posterior lobe of the lung. The cysts are ovoid in form, about the size of a walnut, and whitish-grey in colour. Externally they are covered with a fibrous capsule. Each cyst contains a fluid in which the fluke is found. Found in dogs, cats, and man in China, Japan, and Formosa.

Another large Fluke, *D. magnum*, is found in deer, and decimated the herds in the deer parks at Mandria, in Italy. It seems to have been imported into America, and is now almost as bad in the western plains as *D. hepaticum.*

Bilharzia hæmatobia.—This trematode lives in the veins of the bladder in man, especially in abundance on the east coast and inland parts of Africa from Egypt to the Cape and around Lake Nyassa and the Zambesi river, Gold Coast, Mecca, &c. In Egypt, 30 per cent of the population suffer from Hæmaturia, the disease caused by this worm. It is found in couples, chiefly in the veins of the bladder, pelvic region, and large intestine. The expelled urine is mixed with blood and eggs of the worm. The female is filiform, about 20 mm. long, and is found in a canal along the male, which is white, and from 12-14 mm. long.

Another species, *B. crassa*, infests cattle in Egypt, Sicily, and India, but does not produce hæmaturia.

The *Polystomata* are external parasites, and develop without any alternation of generations such as we have just seen in the liver-fluke of the sheep. Some species live in the bladder of frogs (*Polystomum interrimum*), others live on the gills of fish (*P. lanceolatum*).

Cestoda or Tapeworms.

The Tapeworms are a group of flat-worms which are entirely parasitic in habits. They are segmented, but not in the same sense as we understand the segmentation of the true Oligochæta. There is neither a mouth nor an alimentary canal, as the nutriment is taken in by the process of *endosmosis*, absorption being effected through the skin of the whole body-surface. These cestode worms undergo a curious alternation of generations. The two stages in the cestode life-cycle have often been described under two different names. The two stages are—(1) the adult worm, which is always found living in the intestines of man and various animals and birds, &c.; and (2) the "cystic stage," which is usually found in a totally different host, and in some of the organs or connective tissues of the body, *not* in the intestines. The diseases produced by tapeworms are known as *tæniosis*, and in some cases the disease ends fatally not only in animals but also in man. A well-known instance of this vermiceous group is the disease called "measles in pork," which is produced by the cystic stage of a tapeworm (*Tænia solium*) that invades man. The worm is contracted by eating infested pork insufficiently cooked. Another is the measles in "beef" produced by the cystic stage of the human tapeworm *Tænia saginata* (Goeze), the beef tapeworm.

Tapeworms are found in all parts of the world, and are usually most destructive where insanitary conditions exist. A typical tapeworm (fig. 14, C) consists of a permanent head, known as the *scolex* (figs. 14, *s*, and 12, A), and a long segmented body, each segment being known as a *proglottis* (B). Between the scolex and the body there comes a constricted area, the *neck* (fig. 14, *n*). This is the growing area of the worm, the area from which fresh segments are constantly being budded off. The proglottides increase in size towards the tail end. Each proglottis is practically a perfect animal in itself, as each has a separate set of sexual organs. When the segments are ripe—that is, sexually mature and full of ova—they fall off: sometimes they disunite separately, at others in groups of from four or more, and pass out to the exterior in the animal's excrement.

The *head* or *scolex* (figs. 12, A, and 14, *s*).—This so-called head has no mouth; there are usually two or four suckers (*s*) upon it, enabling it to become attached with the additional aid of two rows of hooks (*h*) to the mucous membrane of the host's intestines. Hooks may be absent. (Unarmed tapeworms, as *Moniezia expansa* of sheep.) In some species the scolex is drawn out in front into a kind of snout, the *rostellum*, and then hooks are present surrounding its apex.

We find four chief modifications of scolices: (i) In the *Tæniæ*, in which there are four suckers and two sets of hooks on the rostellum; (ii) *Bothriocephalus*, in which there are two suckers; (iii) *Acanthobothrium*, which are provided with a complicated set of suckers and beset with numerous hooks; and

(iv) *Tetrarhynchus*, which has four protrusible probosces, also beset with recurved hooks.

The *neck* (fig. 14, *n*).—Here note the first traces of segmentation. At first faint transverse stripes are seen, not extending right across the neck; farther down they pass from side to side, and small segments are thus marked off, becoming larger and more distinct the farther we get from the scolex. The neck is narrow and constricted.

The *proglottides* or segments as they become ripe pass out of the host and lead a free life for a short time: they are the reproductive parts, whilst the scolex and neck are the vegetative parts, of the cestode. Yet each segment is practically an individual animal. The internal structure, like the external, is simple; no alimentary canal will be seen at all; each segment, which may be oblong or square, broad or narrow, according to the species, is nearly solid throughout. Beneath the outer layer or cuticle is a matrix of small cells, in which glandular cells are seen to be dotted about; beneath this is a thin layer of longitudinal muscle, then a parenchymatous mass of connective tissue in which small bundles of longitudinal muscle-fibres are scattered, then a layer of circular muscles, and finally in

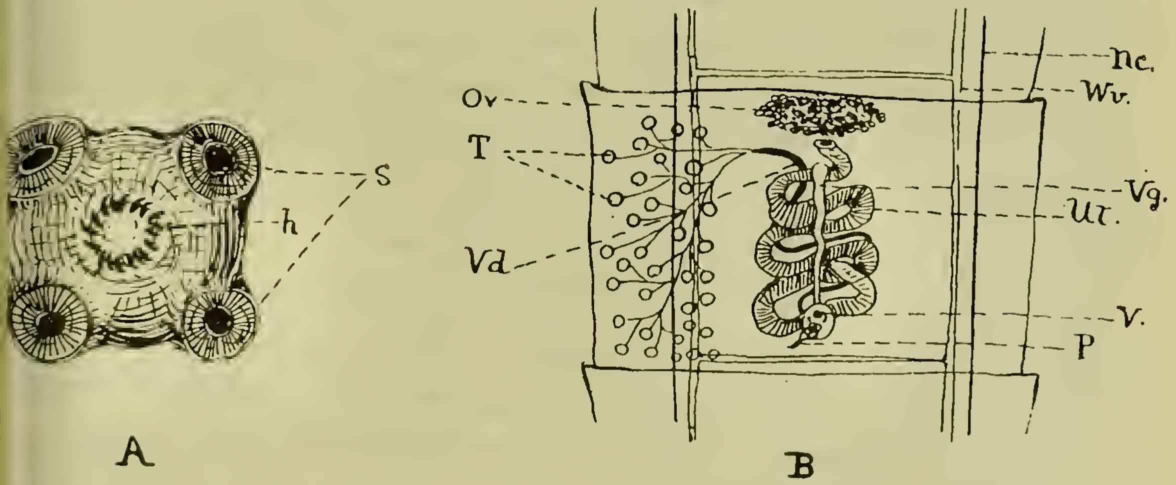

Fig. 12.—Scolex of Tænia solium and Proglottis of Tapeworm.

A, Scolex of *Tœnia solium*, seen from front. B, Proglottis of Tapeworm. S, Suckers; *h*, circle of hooks; *Nc*, nerve-cord; *Wv*, water-vascular system; *Ov*, ovary; *T*, testes; *Vd*, vas deferens; *Vg*, vagina; *Ut*, uterus; *V*, vulva; *P*, penis.

the centre of the segment the organs are embedded in a solid connective tissue. In the first segments we find dotted about calcareous bodies, that are calcified connective tissue-cells. Each segment has its own *generative apparatus*, both male and female organs being found in each proglottis. The male organs consist of a number of pear-shaped bodies, the *testes* (fig. 12, *T*); each of these small round male glands has a fine duct running from it. These *vasa efferentia*, as they are called, unite into a common duct, the *vas deferens* (*Vd*), which is spirally coiled at the end; this portion lying in a muscular pouch, the "cirrus pouch," it can be protruded as the penis or cirrus (*P*). The female organs are more complicated: they consist of two ovaries (*Ov*), yolk-gland, uterus (*Ut*), shell-gland, receptaculum, and vagina (*Vg*), situated as shown in fig. 12. The vagina generally opens into the same cavity as the cirrus, but may be separated from it some distance.

The Tapeworms are also provided with an *excretory system* (fig. 12, *Wv*), which extends as four tubes united transversely in each segment, and finally all uniting and opening by one vesicle at the last segment. The nervous system is very primitive, consisting of two cephalic ganglia in the scolex united by a commissure, and two long lateral trunks (*Nc*) running down each side of the proglottides. We thus see that although each segment is sexually distinct and independent, and that the segments can live a free life for a time, yet they are all united into one animal by the nervous and excretory systems.

Development of Cestodes.—The male organs reach maturity before the female: as soon as they are ripe, copulation takes place, and the receptacle of the female becomes filled with sperm, and then the female organs mature.

The ova when fertilised pass into the uterus, which becomes very distended, and the rest of the proglottis becomes absorbed, —in fact the whole segment is filled with eggs. In the uterus the eggs in the last segment are said to become free embryos; but this the writer has failed to detect in the many species of

Tapeworm examined. The eggs are round or oval and small. The shell of the egg may be composed of several thin membranes or of a thick and strong capsule. The curious six- or four-hooked embryo (fig. 14, B) may be seen in the most highly developed ova. In one genus of Tapeworms, known as *Bothriocephalus*, of which a species is found in the human being in Switzerland and elsewhere, the development takes place partly in the water, the embryo leaving the ovum as an oval ciliated larva. As a rule, we find that a complete metamorphosis exists, which is often connected with a very complicated "alternation of generations." The subsequent stages live in different localities, finding the necessary conditions in different animals or "hosts," between which they migrate either actively or passively.

The ripe proglottides break off from the worm and are passed out of the host in its excreta, where they remain on dunghills, on the grass, and in water. The proglottides burst by cadaveric decay, and the countless number of contained ova are disseminated over the surface of the earth and in the water; here they remain until they are taken into the body of some *herbivorous*, *omnivorous*, or, more rarely, *carnivorous* animal.

When in the stomach the gastric juice dissolves the capsule of the ovum, and the round embryo is set free with its six, or rarely four, hooks. These hooked embryos bore their way into the gastric and intestinal vessels, when they enter the vascular system and are carried along passively by the flow of blood, and then pass by way of the capillaries to the lungs, liver, muscles, brain, &c., of the animal that has had the misfortune to ingest the ova. The embryos then take up their abode in some organ or connective tissue of their host, lose the hooks, and become converted into *cysts*, *hydatids*, or "*water-bags*," which grow into large vesicles with liquid contents. These vesicles become in time what are called *Bladder-worms*, by the formation of one or more hollow buds which are developed from the walls of the cyst, and which project into its interior. The armature of the future scolex is developed at the bottom of these invaginations. By a process of evagination we see that the true scolex and neck are found attached to the bladder or vesicle.

Varieties of cysts.—When only one invagination is formed, the cyst is known as a *Cysticercus* (fig. 13, A); when several are produced, as a *Cœnurus* (B); and when the cyst itself produces other cysts, and each of these secondary cysts gives rise to smaller invaginations (scolices), the structure is called an *Echinococcus* (fig. 17). These structures, so formed, may live in an animal for a very considerable time; but unless they are taken into the body of some other animal, they must eventually die. Should a carnivorous or insectivorous animal, or such an omnivorous one as the pig, or even man, devour in the meat that they eat any of these cystic forms, the action of the gastric juice, again acting upon the cestode, dissolves the walls of the "bladder," and releases the rudimentary scolex or scolices formed in it. These heads of future tapeworms then pass into some portion of the intestine, and by means of the hooks with which they are provided, and augmented by the suckers, they anchor on to the lining mucous membrane of the small and large intestines. As soon as the embryo has taken up its abode on the mucous membrane the scolex commences to bud off

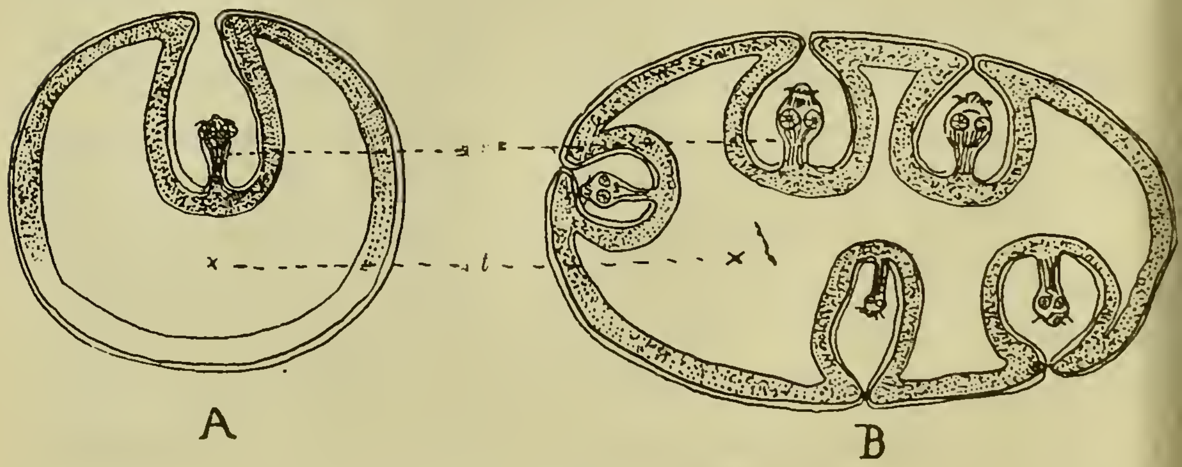

FIG. 13.—TWO FORMS OF CESTODE CYSTS.

A, A *Cysticercus* (after Neumann). B, A *Cœnurus*.
s, scolices; *t*, cavity of cyst.

segments, formed by an asexual budding in the longitudinal axis, and resulting in the formation of a mature sexual cestode or tapeworm, which may in some species reach as much as thirty feet in length. At one time tapeworms were considered colonial animals, each proglottis being a distinct individual; but since it is the scolex which grows, we must consider that the whole is an individual, and that the individuality of the proglottis is subordinate to it,—and, moreover, we find one excretory and one nervous system common to the whole.

The typical development is then a true metamorphosis: it is only when many scolices are produced from the one embryo asexually that the development is a case of the remarkable "alternation of generations." The simplest development is found in the genus *Bothriocephalus*, where it is more or less direct, the embryo becoming immediately a scolex. In some other forms we find that in the Cysticercus stage the vesicle or bladder becomes small and is nearly lost; no segments are formed, the Cysticercus becomes converted into the *Cysticercoid* form, in which that portion of the scolex bearing the hooks is separate from that part with the suckers.

Positions in which Tapeworms and their Cysts and Ova are found.

1. Cysts are found in the liver, lungs, muscles, brain, spinal cord, kidneys, eyes, thoracic cavity, body cavity generally, and in the hepatic ducts.
2. Tapeworms are found only in the small and large intestines and stomach.
3. The ova are met with on the ground, on grass, on dunghills, and in water.

The cyst stage is, as a rule, found in herbivorous animals, but also in man, fish, and in various species of insects. The dog, for instance, has one of its tapeworms living in the cystic stage in the louse (*Trichodectes*).

Various Forms of Tapeworms of Economic Importance.

Multiceps multiceps. Hall.
= *Cœnurus cerebralis* = *Tænia cœnurus*
(which causes the Sturdy, Gid, or Staggers in Sheep).

In dogs, especially in sheep-dogs, we commonly find a tapeworm known as *Tænia cœnurus* (fig. 14, c). This worm, which may also exist in other animals, such as the fox, lives in the intestines. There is no proof yet, however, that the fox does harbour this worm. It can be distinguished by having a circle of hooks around its head, which is slightly drawn out into a rostellum, and by its four suckers. In length it varies from twelve to sixteen inches when adult, and is constituted of about two hundred distinct segments. The pale proglottides full of eggs are passed out on to the ground in the sheep-dog's excrement, and there remaining for a short period, they burst, re-

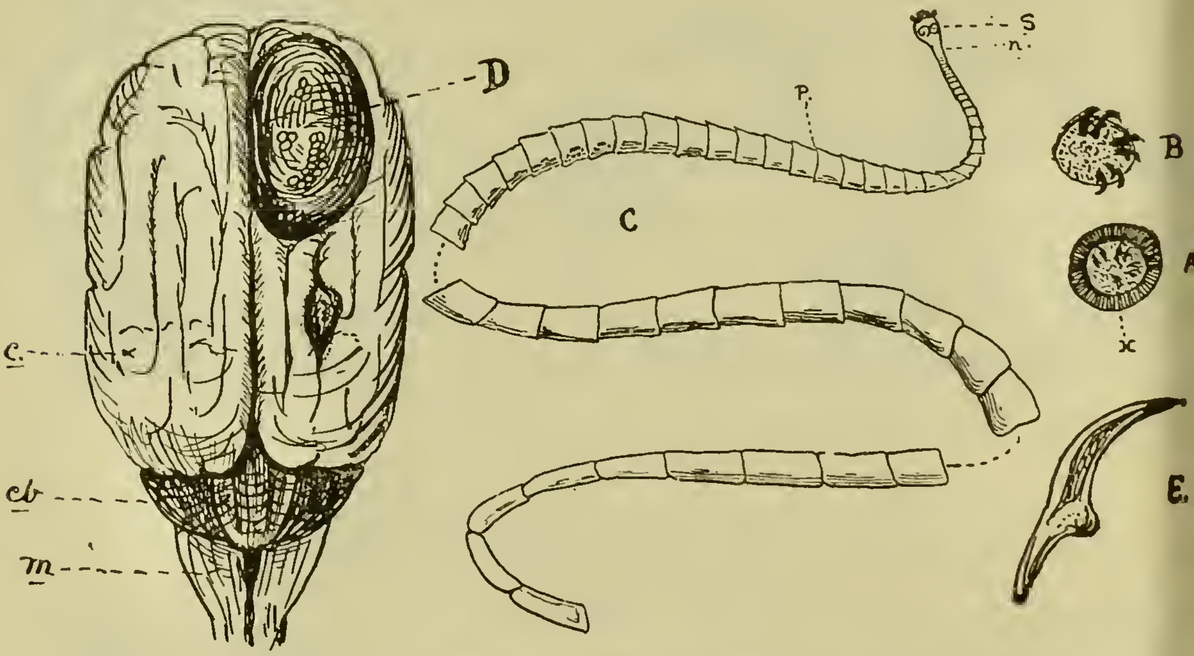

Fig. 14.—Sturdy in Sheep
(*Multiceps multiceps* and *Tænia cœnurus*).

A, Ovum. B, Embryo. C, Sexual worm (*Tænia cœnurus*): *p*, proglottides; *n*, neck; *s*, suckers. D, *Multiceps multiceps*: *c*, cerebral hemispheres; *cb*, cerebellum; *m*, medulla. E, Hook from C.

leasing thousands of ova (A). These are taken off the grass by the lambs, or even two-year-old sheep; sometimes even whole segments may be devoured. Cattle, goats, antelopes, chamois, gazelles, and the horse are also sometimes affected. The embryos become released in the stomach of the sheep or other animal. The six-hooked larvæ then commence to bore their way through the walls of the ovine intestine, and finally enter the blood, by which they are carried to various parts of the body. Should any of these embryos reach the brain or spinal cord, as very often happens, further development takes place; otherwise they apparently die a premature death. After the larva has reached the cranium, it commences to burrow about until it finds a suitable resting-place for further growth. A brain examined fresh, when it has been invaded by one or more of these larvæ, shows red sanguineous streaks on its surface, very like the innumerable fine blood-vessels which ramify over it,—these tracts have been formed by the moving embryo worms. On taking up its fixed abode, the larva then grows into the *Bladder-worm*, the so-called hydatid, or "water-bag" of the shepherds, which gradually swells until it reaches the size of a walnut, or even larger. The writer has twice taken these cysts from lambs nearly as large as an egg, the hosts, needless to say, having died. Often several cysts are found in the brain, both on its dorsal and ventral moieties. Each of the cysts, which were formerly known as *Cœnurus cerebralis* (now as *Multiceps multiceps*), develops from three hundred to four hundred scolices by asexual budding. These can easily be seen in the "hydatid" as minute white specks. The affected sheep gradually lose their power of equilibrium, turn round and round, and fall down. In the early stages of infestation the lambs shake their heads and hold them on one side; but as the "bladder" grows the symptoms become more marked. These cysts are also found in the spinal cord. Spontaneous recovery may take place, but large numbers of sheep are annually lost by this parasite; and yet we do little or nothing to prevent it, when prevention lies easily in our power.

Should a human being eat the diseased brain, cyst and all, no further development would take place, but he does not do so. What generally happens? The dead animal or head of the "pothery" or "sturdy" sheep is invariably thrown into the nearest wood or spinney or given to the shepherd's dog. What is the result? The cyst, being only capable of development in one of the *Canidæ*, produces numbers of the tapeworm, *Tænia cœnurus*, in the dog's intestines, and so the disease is propagated; whilst if the diseased heads were destroyed or given to fowls, in which the scolices, I find, never develop, all that persistent loss would be saved. The cysts are often found in the lumbar region of the spinal cord, where they may reach a great size, and produce the so-called "lumbar-gid"—the hindquarters becoming paralysed. The only treatment is trephining, but it is seldom done, and it is far better to kill the parasitised animal.

Tænia solium = *Cysticercus cellulosæ*
(the Human Tapeworm and Measles in pigs).

Tænia solium is a tapeworm found in man, in some parts of Europe in great abundance, but comparatively rarely now in England. It is creamy white in colour, and reaches from six to ten feet in length, often being composed of as many as eight hundred segments: the scolex is provided with a large circle of hooks. The ripe segments become pinched off several together and are passed out, when they may find their way on to some dung-heap. If a pig happens to come across them they are speedily eaten, and hundreds of the contained ova are dehisced into the stomach, and give rise to the typical six-hooked cestode embryos. These enter the vascular system in swarms and take up their abode in the muscles, or rather in the connective tissue between them. Sometimes they even reach the brain and spinal cord, and may also be found in adipose or fat tissue. These embryos form small watery cysts about the size of peas, especially in the loins, and give rise to the disease in pigs known as "measles." From ten to twenty thousand cysts (fig. 15, *c*) have been counted in one pig. Should this "measly pork," which is condemned in the markets, be eaten by man, each one of those cysts will become converted into the obnoxious human pest,

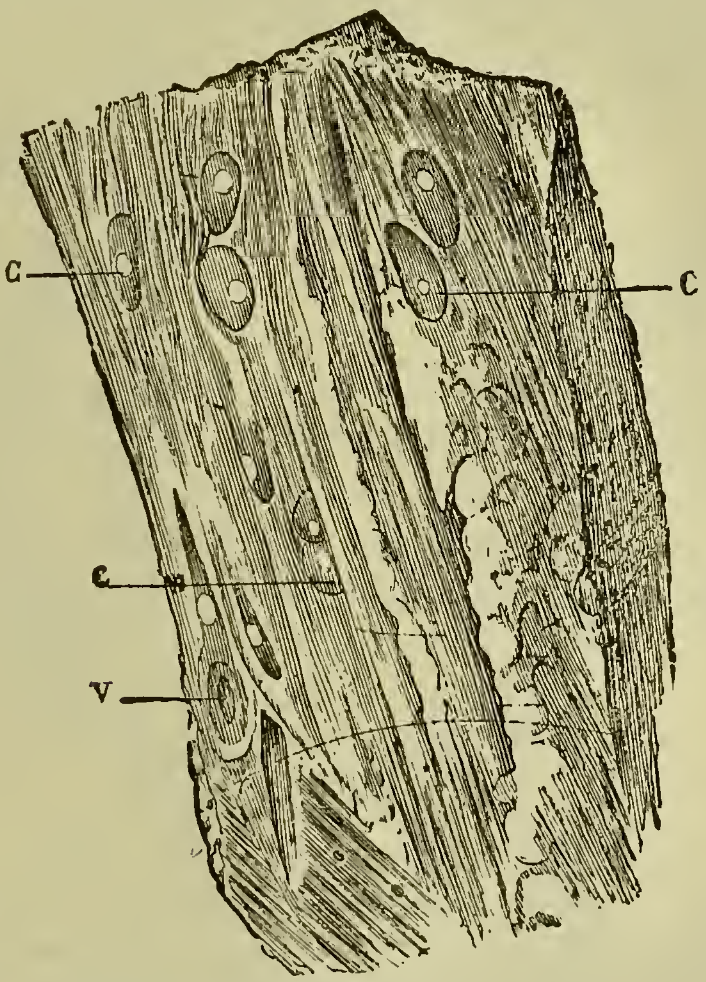

FIG. 15.—FRAGMENT OF MEASLY PORK.
c, *c*, Cysticerci; *v*, alveolus, from which a bladder-worm has been taken. Railliet. (From Par. Dis. Ani., Neumann.)

Tænia solium. The cystic stage is also said to be found in man in his eyes, brain, and muscles. The disease is still persistent in some Continental districts and in Ireland; but, owing to our more sanitary ways of living, its effects are being less felt than formerly. It is a disease that has been observed for a very long period, being well known, although not understood, by the ancients.

Echinococcus.—A third type of cyst known as Echinococcus often assumes a great size. The sexual tapeworm that produces this cyst is *Tænia echinococcus* (Sieb.), fig. 16. This worm is found in the dog, and is very prevalent. It is minute in size, seldom exceeding one-fourth of an inch in length, and is composed of never more than three elongated segments. The last segment, which is much the largest, contains numbers of ova when mature. The head is provided with a double row of hooks. The colour is creamy-white, and they may be found in great numbers in the fluid contents of the dog's intestines, and are often seen sticking round the anus. These worms are derived from the cysts known as *Echinococcus veterinorum*, found in herbivorous animals and man, but especially in the Ruminants. The worms reach maturity in about a month after the entry of the cysts into the stomach of the dog. The cyst *Echinococcus veterinorum* (Sieb.) is the same as *E. polymorphus* of Diesing. They are to be met with in man, monkeys, cats, dogs, rabbits, sheep, oxen, goats, horses, deer, and many other animals; but ruminants and pigs are the greatest sufferers. Man in certain districts, especially in Iceland and in Mecklenburg, has often suffered seriously from this so-called *Hydatid* plague. Although Echinococcus is met with in all parts of the body, it is the liver that is chiefly invaded: occasionally much pathologic disturbance is also caused by them in the lungs and in the kidneys.

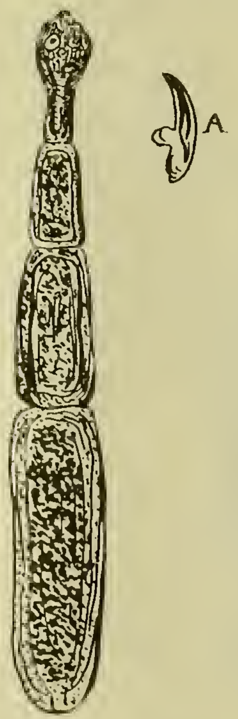

Fig. 16. — Tænia echinococcus.

A, Hook from same. (Greatly enlarged.)

The ova of *Tænia echinococcus* are passed out with the ripe proglottis from the dog's bowels and get into the water. On entering the herbivorous or omnivorous host the ova hatch, and the embryos make their way *viâ* the portal system to the liver. They there produce small white cysts, which contain a vesicle. Development proceeds very slowly. By the end of five months, Leuckart has shown that they attain the size of a walnut. They now consist of a whitish-yellow vesicle with thick walls composed of two layers (fig. 17) —the outer one thick, and called the hydatid membrane (*ct*); the inner one thin (*m*), and known as the germinal membrane. Internally this "mother-vesicle" contains a colourless neutral fluid. In some cases the "mother-vesicle" remains in this state, no scolices being produced, when it is called an "acephalocyst." Should further development take place, as is usually the case, a number of buds, close together, arise from the germinal layer (*vp*). These buds become hollow, and from their internal walls scolices appear. As many as thirty scolices may be formed in each of these

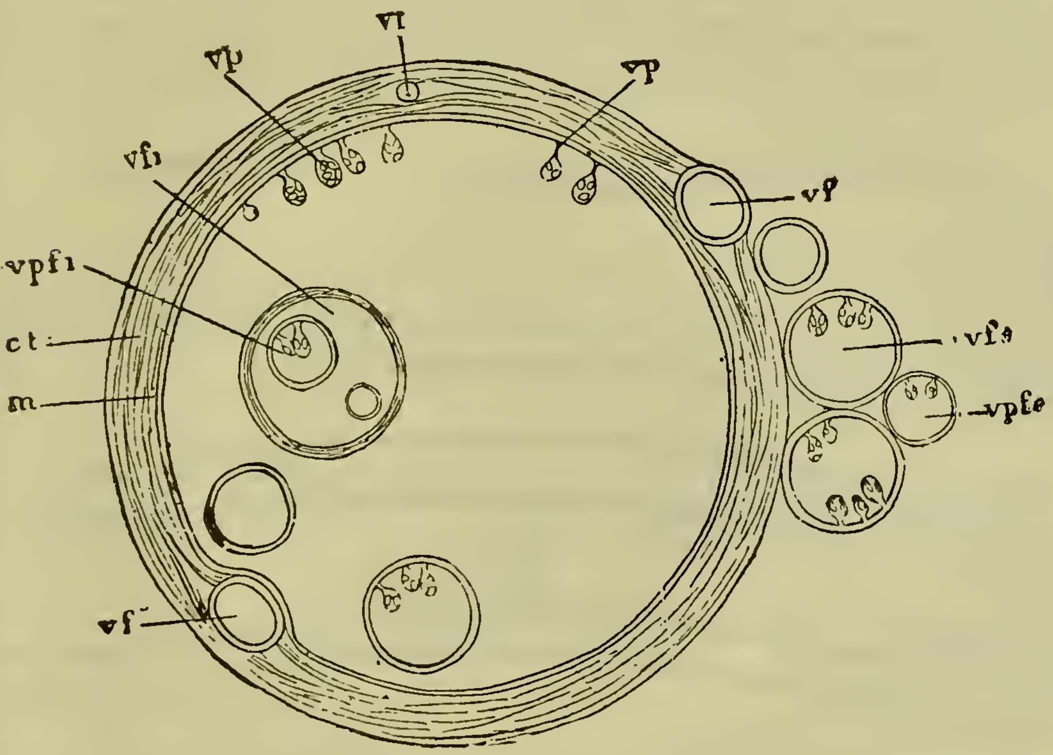

FIG. 17.—DIAGRAM SHOWING FORMATION OF PROLIGEROUS AND SECONDARY VESICLES IN ECHINOCOCCUS. Railliet.

ct, Hydatid membrane; *m*, germinal vesicle; *vp*, proligerous vesicles; *vf*, daughter-vesicle commencing to form; *vf'*, daughter-vesicle passing externally; *vf''*, daughter-vesicle passing internally; *vfi*, internal daughter-vesicle; *vfe*, external daughter-vesicle; *vpfi*, internal grand-daughter-vesicle; *vpfe*, external grand-daughter-vesicle. (From Par. Dis. Ani., Neumann.)

proligerous vesicles, and they may break away and float in the fluid contents of the cyst.

Secondly, there are formed in the hydatid membrane (*ct*) cavities (*vf*), which gradually become larger and pass either internally (*vf″*) or externally (*vf′*) ; these are secondary or *daughter-vesicles.* As a rule, we do not find internal and external daughter-vesicles in the same hydatid. These secondary or daughter-vesicles may produce proligerous vesicles, and thus scolices, internally (*vfe*). Some do not produce scolices but other vesicles, grand-daughter-vesicles (*vpfi* and *vpfe*). These grand-daughter-vesicles may again form internal proligerous vesicles, and thus scolices ; or they may remain as acephalocysts, just as the primary proligerous vesicle does occasionally.

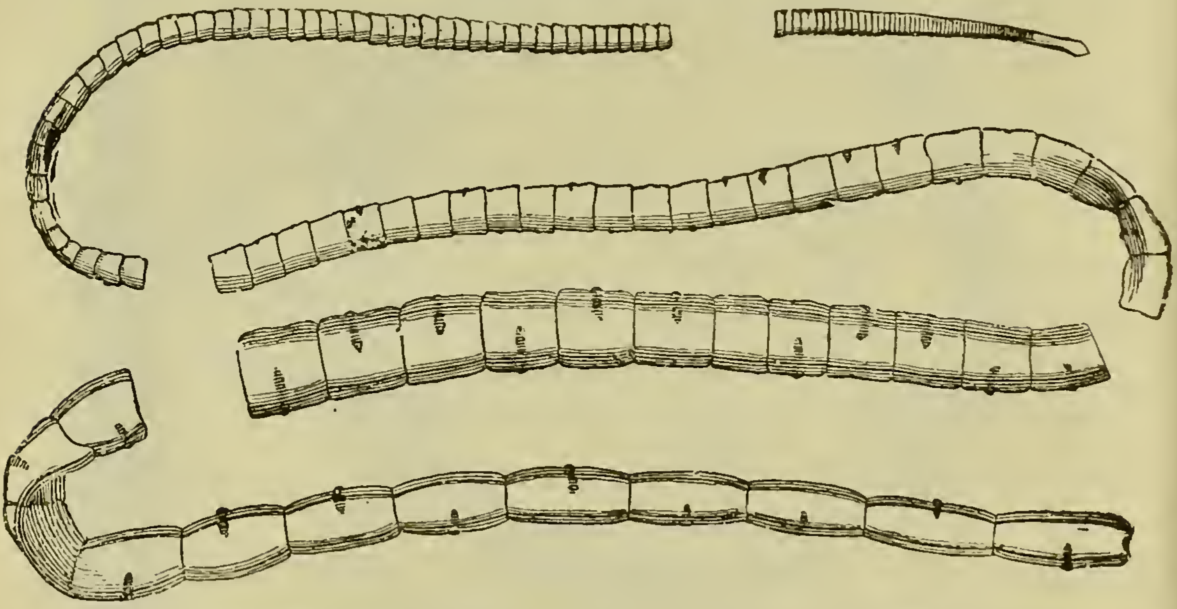

FIG. 18.—TÆNIA SERRATA (nat. size). (From Par. Dis. Ani., Neumann.)

It will thus be seen that one ovum of *Tænia echinococcus* may produce hundreds of scolices, future tapeworms, should a dog devour the organs suffering from this echinococcosis.

Lastly, there is a form of Echinococcus known as a *multilocular* form, in which the vesicles remain very small, whereas in the others they may assume an immense size. These vesicles remain attached together, and may produce a huge mass eight or nine inches across, united together by connective tissue.

These are called colloid cancers, but Virchow showed some time ago their true formation.

The secondary internal vesicular formation is chiefly found in man, the pig, and the horse, where huge hydatids are produced. Secondary external vesicles are more general in ruminants, but they also occur in the pig and in man. This disease is found wherever dogs exist. One-sixth of the population in Iceland have suffered from this plague.[1] It is also abundant in Australia,[2] India, and elsewhere. It is by no means uncommon in Great Britain.

Other Tapeworms.

Numerous other tapeworms exist in domestic animals and man. At least fourteen are found in the dog and ten in man. *Tænia serrata* (fig. 18) is often very common. Its cystic stage (fig. 19, *d*), known as *Cysticercus pisiformis*, is found in the peritoneal cavity of rabbits and hares. Dogs obtain this worm

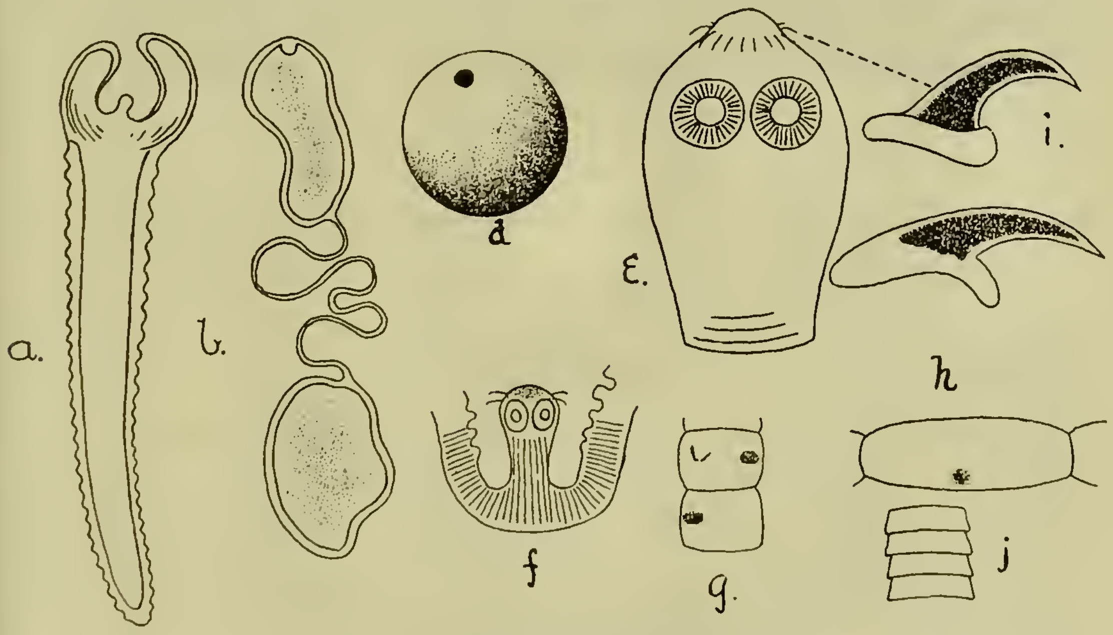

FIG. 19.—TÆNIA SERRATA.
a, Young Cysticercus; *b*, same dividing; *d*, mature *Cysticercus pisiformis*; *e*, scolex and hooks of *T. serrata*; *g*, *h*, *j*, various segments; *f*, scolex in *Cysticercus*.

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[1] Dobell, Report on Iceland. (1879.)

[2] Thomas, Hydatid Disease in Australia. Adelaide (1884).

by eating the viscera of those animals. Sheep have also several parasitic within them, which produce scouring and emaciation. *Moniezia expansa* is often troublesome in sheep, both in England and America; it also occurs in cattle. The life cycle is not known.

"Measles" in beef is also due to a cyst called *Cysticercus bovis*, which occurs in the skeletal muscles, heart, lymph glands, and even between the convolutions of the brain and the lungs and liver. The sexual stage is the tapeworm *Tænia saginata*, the unarmed tapeworm found in man. It is almost cosmopolitan, being very prevalent in Africa and Asia. It frequently reaches 7 metres long.

Tæniosis is also sometimes a very troublesome complaint in fowls, but so far has received little notice in this country.

The third order of Platyhelminthes does not concern us: they are called **Nemertini**, most of which are free-living worms, a few being parasitic in the mantle cavities of various mollusca.

CHAPTER V.

WORMS—*Continued.*

NEMATHELMINTHES OR ROUND-WORMS.

THE Round-worms have a tubular and filiform body. The cuticle, or outer layer of skin, is ringed but never segmented. The sexes are separate, the male worm being usually quite distinct from the female. The alimentary canal may be absent or rudimentary, but is generally present and well developed. There are no special organs of respiration or circulation. Amongst these round-worms innumerable parasitic forms are found in man and the domestic animals, as well as in fish and insects. Many fatal diseases are produced by them, such as trichinosis in man and pigs, gapes in poultry, husk or hoose in lambs, &c. The horse is very subject to a number of species. These worms taper to a point at each extremity.[1] We shall frequently observe special organs for attachment on both the anterior and posterior regions, such as hooks, teeth, and even suckers, which are used by the worms not only for holding on to their host, but also for purposes of copulation. The integument of these round-worms has a thick cuticular layer, and also a large muscular layer within, by means of which the body is enabled to wriggle, undulate, and knot itself into fantastic forms. Although vascular and respiratory systems are seemingly wanting, yet a nervous system exists. Here also we shall observe sense-organs in the form of simple eyes in those forms that are free-living, but not in the parasitic species. In some, such as the *Acanthocephala*, the mouth and alimentary canal is entirely absent, whilst in the *Nematodes* a true digestive system is developed. Many of the Nemathelminthes develop without any metamorphosis. Where larval forms occur the larvæ are often found in different hosts, and in any case in different parts of the same host.

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[1] Except in the Strongylidæ, where the posterior end of the male culminates in a cup-shaped bursa.

Nematoda.

The round-worms which we have especially to consider in this work are the *Nematodes* or Thread-worms, which include various parasites in animals and birds, as well as in man, and also parasites that attack plants.

The body of Nematodes is thin and thread-like, hence their popular name "Thread-worms." The mouth leads into an œsophagus which has thick muscular walls and often a chitinous lining, and is frequently dilated behind into a muscular bulb, the pharynx. The intestine following the pharynx opens by a posterior pore, the anus, on the ventral surface. In a transverse section of a nematode the muscle is seen to be divided into four areas, broken at the sides by the two lateral lines in which run the excretory canals, and above and below by a dorsal and ventral line. Nematodes are always of separate sexes, never hermaphrodite as in the Flat-worms, except in one or two notable exceptions, in which first male cells—spermatozoa—and then female cells—ova—are formed in the same individual. Male nematodes are always smaller than the females, and have the posterior end of the body curved; moreover, they are usually provided with a pair of recurved hooks for attachment to the female (fig. 21, *d*). Nematodes increase by true sexual reproduction.

Sexual reproduction consists of the union of a male cell which is known as a sperm cell or *spermatozoon* with the female or *germ cell*; the result of the fertilisation—that is, the entry of the male element into the female—is the production of a fertile *ovum*. The female cell is sedentary, the male is active, the latter being usually armed with a whip-like tail resembling in some respects a flagellate protozoan, but the whip pushes the flagellata, whilst it pulls the spermatozoa. The male cell enters the female cell and then loses its flagellum. On the entry of the spermatozoon into the germ cell, the former travels through the latter until it unites, or rather its nucleus unites, with the nucleus of the female cell, or, as it is more correctly called, the female pronucleus. One spermatozoon alone enters: the entrance takes place through an aperture in the germ cell called the micropyle. At the same time a prominence appears on the ovum, called the "polar prominence," which gradually grows out and splits off into two round bodies, the "polar bodies," which pass away and are lost. The result is that a fertile ovum is produced, capable of developing into an individual similar to the male and female parent form, and yet sufficiently plastic to undergo slight variations which may become permanent characters, and so eventually mould a new species. An asexual egg passes out only *one* "polar body," a true ovum *two*.

Development of Nematodes.—Nematodes chiefly lay eggs (fig. 20). Living young are produced by a few species, when they are called viviparous, to distinguish them from the egg-laying or oviparous species. The ova possess a shell, but in the *Trichinæ* this is lost whilst in the mother worm. Fertilisation takes place by the entrance of a spermatozoon into the female cell while it is still without the shell membrane. The ovum on being fertilised

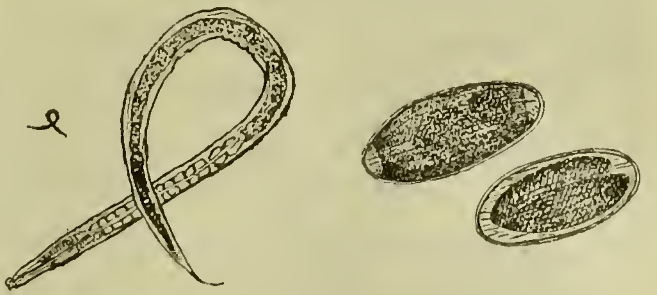

Fig. 20.—Embryo and Ova of Sclerostomum rubrum. (Greatly enlarged.)

then commences to go through the process of *segmentation*, which is the result of the rapid division of the nucleus and the formation of a number of cells in the ovum. The cell division is equally distributed throughout the egg—that is, the segmentation of the ovum is equal. Eventually from this segmented ovum two cell layers are formed: these two layers become invaginated or pressed in at one end, and there is thus formed an embryo known as the *gastrula*. From the two cell layers of this gastrula are developed the body-wall and alimentary canal. The young may encyst in an intermediate host, and in the cyst stage are transferred to the permanent host: for instance, *Spiroptera obtusa* in the mouse is derived from cysts of this species in the meal-worm—the larva of a beetle which lives in flour, biscuits, and meal, and there eats the ova passed out by the mouse. A large number of these round worms develop direct.

Lastly, we may have changes taking place in the same animal, the worms migrating from the intestines to the parenchymatous tissues, as we shall observe happens in the case of *Trichina spiralis* in pigs.

There is one very important group of Nematodes to the farmer, which develop and live in damp earth and plants. These cast their skin whilst in the damp earth and are converted into what are known as "Rhabditis," forms which have a double enlargement of the œsophagus and teeth attached to the pharynx. Some become sexually mature in the earth, and their offspring again migrate and live as parasites; others undergo several ecdyses, becoming mature in the permanent host. The embryo gradually elongates and becomes coiled up in the shell (fig. 21, *c*). The free development may be in the form of a metamorphosis which happens away from the parent form.

The larvæ, parasitic in animals and man, live in the parenchymatous organs of their host, either free or encysted in connective tissue capsules; whilst the adults live chiefly in the alimentary canal.

The embryos often have a curious boring tooth in front, or a circle of spines. They moult their skin: frequent ecdyses or moults precede the adult stage. The simplest form of development is where the embryo, enveloped still in its egg-membrane, is transported, passively, in the food to the host (*Oxyuris*). In the *Ascaridæ* the embryo, which is provided with a boring tooth, may pass sometimes into an intermediate host, by which it is transported with its host in food and water into the second host, where it will become sexually mature.

The *food* of Nematodes which are parasitic consists of the organic juices of the body. They nearly all seem to lead a free life during some period of their existence. Those that are parasitic in plants, causing such diseases as clover-sickness, ear-cockles or purples in corn, &c., are called eelworms. Many of these eelworms, however, only live in decaying parts of plants, where they do no harm: these are termed *saphrophytes.* Yet others produce fermentations, such as the Vinegar- and Paste-Eelworms.

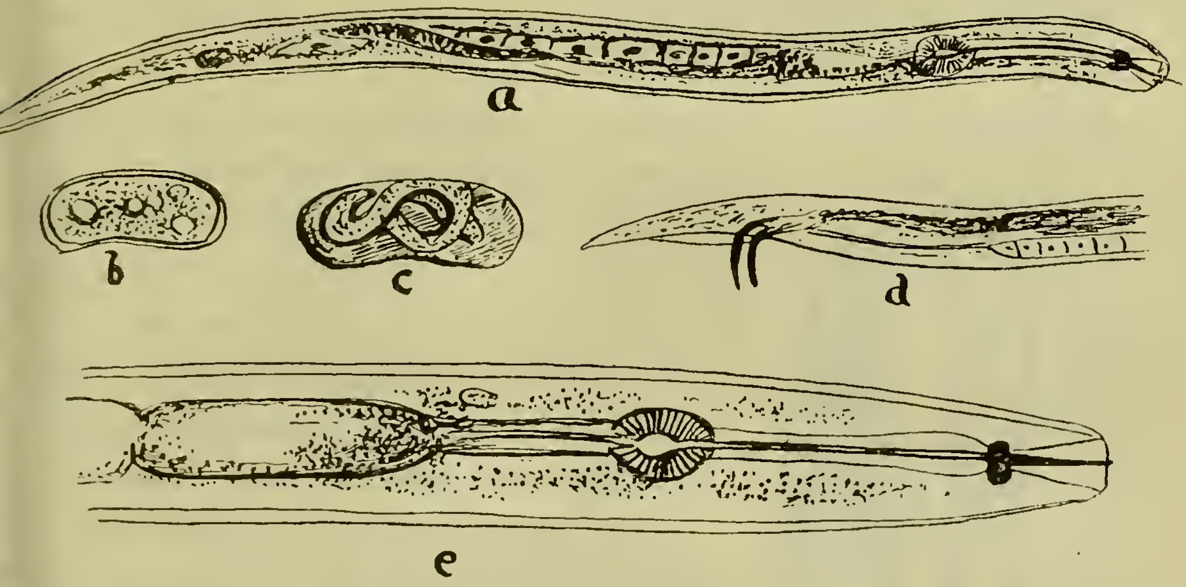

FIG. 21.—ANGUILLULIDÆ (Eelworms).
a, Mature ♀ with oral spine; *b* and *c*, ova; *d*, extremity of ♂; *e*, anterior of adult. (Enlarged, after Ritsema Bos.)

In all cases both egg and cyst of these Nematodes have the power to resist extreme heat and cold, unless it be that the former is kept up for some time.

Groups of Nematodes.—The groups or families of Nematodes of importance to the agriculturist are—

(i) The *Strongylidæ* or Palisade-worms.
(ii) The *Trichotrachelidæ* or Whip-worms.
(iii) The *Ascaridæ* or Round-worms.
(iv) *Filaridæ* or Thread-worms; and
(v) The *Anguillulidæ* or Eelworms.

The first four groups live as parasites upon animals, the last group lives upon plants.

STRONGYLIDÆ OR PALISADE-WORMS.

These worms produce many complaints in animals. They are elongated and spindle-shaped, the anus being placed near the tip of the body, and, as in all Nematodes, the anus and male opening are one and the same. In these Palisade-worms this male opening is surrounded by a curious cup-shaped bursa, which is kept expanded like an umbrella by stiff ribs (fig. 22, E). The female has a pointed posterior (fig. 22, D).

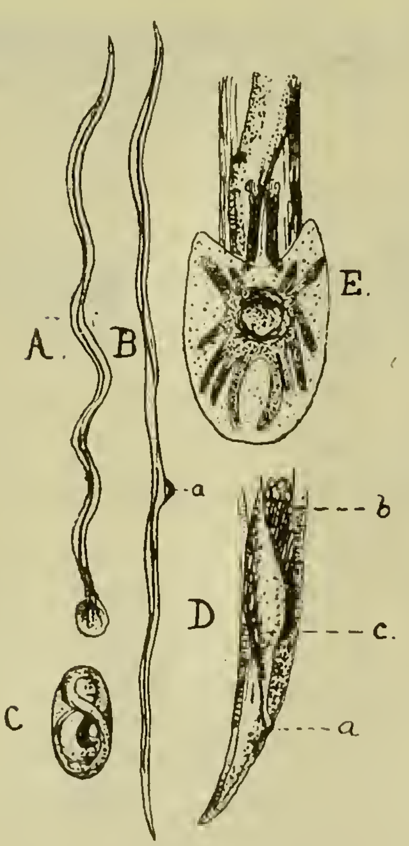

FIG. 22.—THE LUNG WORM (*Strongylus filaria*).

A, Male; B, female; C, ovum; D, enlarged extremity of ♀; E, bursa of male. *a*, anus; *c*, intestine; *b*, uterus.

Lung Worms of the Sheep.

One of the most important and destructive Palisade-worms is the Lung-worm of the lamb (*Strongylus filaria*), a white worm which causes the disease known as "husk" or "hoose." The male worm is about an inch and a half to two inches in length, the female quite three inches. The embryos of these worms are found in damp earth, and enter the lambs during May, June, and July. Strongylosis of the air-passages is generally observed from March to October. They get into the throat and enter the trachea; here they burrow into the mucous membrane and form lumps, which they quit at the end of the winter. The female then gives rise to numbers of living young, hundreds of which may be found in the mucous membrane of the lamb's throat. The young develop partly in water or damp earth before they become sexually mature. Sir George Brown says that in common with other Strongyles they are swallowed by earthworms, and again ejected after having gone through certain changes. Only some of the hosts of embryos ejected can go through earthworms, however. He then suggests that some may become parasitic in plants before they take up their abode in the warm-blooded host. *Filaria* gives rise to vermiceous bronchitis.

We find at least three other worms in the lungs of sheep—namely, *Pseudalis ovis-pulmonalis*, a small coiled worm forming tuberculous-like growths over and in the lung in which they live; and *Strongylus rufescens* and *S. paradoxus*, free in the lung cavities, &c. Whether there is any connection between *S. rufescens* and *P. ovis-pulmonalis* is not known: from what I have observed I consider them quite distinct. *S. rufescens* produces a kind of pneumonia. Two varieties of this disease may be noticed—viz., (1) a lobular pneumonia produced by adult worms in the bronchi, and (2) a diffuse pneumonia caused by ova and embryos in the parenchyma of the lung. *P. ovis-pulmonalis* produced a nodular pneumonia. *S. paradoxus* is of exceptional occurrence.

Stomach Worms of Sheep and Cattle.

Several species of Strongylidæ often occur in enormous numbers in the stomach of sheep and cattle and cause parasitic gastritis. One of the commonest is the *Hæmonchus contortus* of sheep, which also infests cattle and goats. Lambs are specially infected. This worm occurs in the abomasum or fourth stomach.

It is widely spread over Europe, Africa, Asia, Australia, and America. In colour they are white to creamy white; a few may be tinged with pink. Adult females reach from 20 to 30 mm. in length, the males from 10 to 20 mm. They are cylindrical, bluntly attenuated towards the head end, pointed at the tail end in the female; at the head end are two backwardly projecting papillæ. The male has a trilobed bursa and no spiculæ. In the female the ovaries, &c., are spirally wound around the intestine, giving the worm a very marked appearance.

Eggs and young are passed out on to the ground in the fæces. Whether development is direct or not has at present not been demonstrated. The other abundant species are *Ostertagia ostertagi*, found in the fourth stomach of cattle in Europe, United States, and New Zealand. *O. circumcincta*, found in the fourth stomach and intestine of sheep and goats in Europe, America, and Australia.

The genus *Trichostrongylus* is represented by *T. extenuatus*, causing verminous gastro-enteritis in cattle and sheep, also found in the fourth stomach. The life-cycle of these nematodes, which often occur in countless numbers, is not known.

The Armed Strongyles of the Horse.

Another large Palisade-worm, known as the Armed Palisade-worm (*Sclerostomum armatum*) (fig. 23), is found in the lower parts of the horse's gut, chiefly in the cæcum and colon. It is taken in by the horse in polluted drinking-water as a very minute immature worm. This embryo bores into the blood-vessels, enters the large posterior arteries, especially one known as the "anterior mesenteric artery," where it produces a swelling in the wall of the artery (fig. 24). This growth checks the circulation, and may lead to vascular disturbances of some importance. Whilst in this abode the worm is immature; but just before maturity is reached the worm escapes, makes its way through the gut wall, matures, and copulates. The ova are carried out in the dung. The embryos are seen to develop in damp mud and in water, and are thus taken by the horse. The female is often as big again as the line representing the natural size in the figure. Another form, the Giant Palisade-worm (*S. gigas*), is a red worm nearly a foot in length in the female, and lives in the pelvis of the kidney in both horse and man. Sometimes severe epizootics of these Palisade-worms break out.

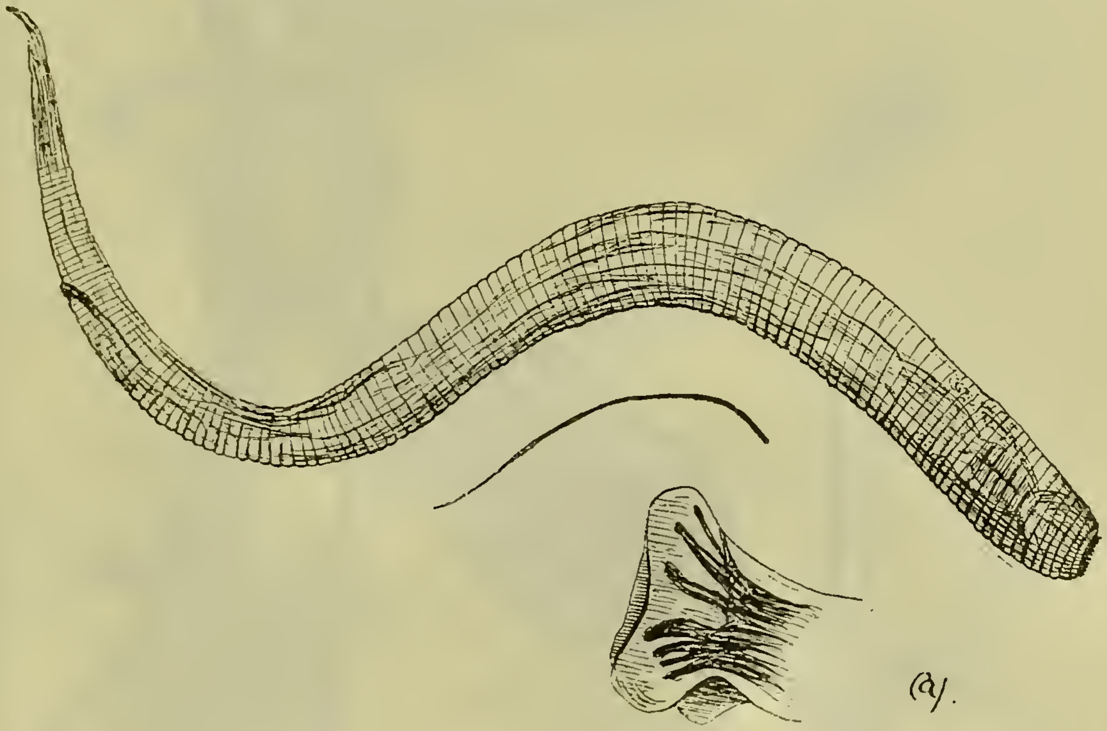

FIG. 23.—ARMED PALISADE-WORM OF HORSE (*Sclerostomum armatum*). Female. *a*, Male bursa. (Line nat. size.)

Sclerostomum tetracanthum (fig. 25) and *S. rubrum* (fig. 26) are usually the most injurious Strongyles in the horse. The former is a pinkish- or brownish-white worm, varying from 8 mm. to 16 mm. in length, the male being smaller than the female, and provided with a bursa excised on the ventral surface, the female having a pointed tail. On each side of the body, a little in front of the end of the œsophagus, is a long, lateral, spine-like body. *S. rubrum* is very similar, but is always red in colour and smaller in size, and has no lateral spines. These two Sclerostomes have a similar life-history.

They do not enter the blood as does *S. armatum.* The eggs are introduced in water, and probably forage, and give rise to embryos which encyst direct in the walls of the cæcum and colon, where they form tumourous patches similar to *S. armatum.* Here lying in the cysts the white coiled worms (fig. 20) produce inflammation, colics, and serious anæmia. When mature they make their exit, and live for some time

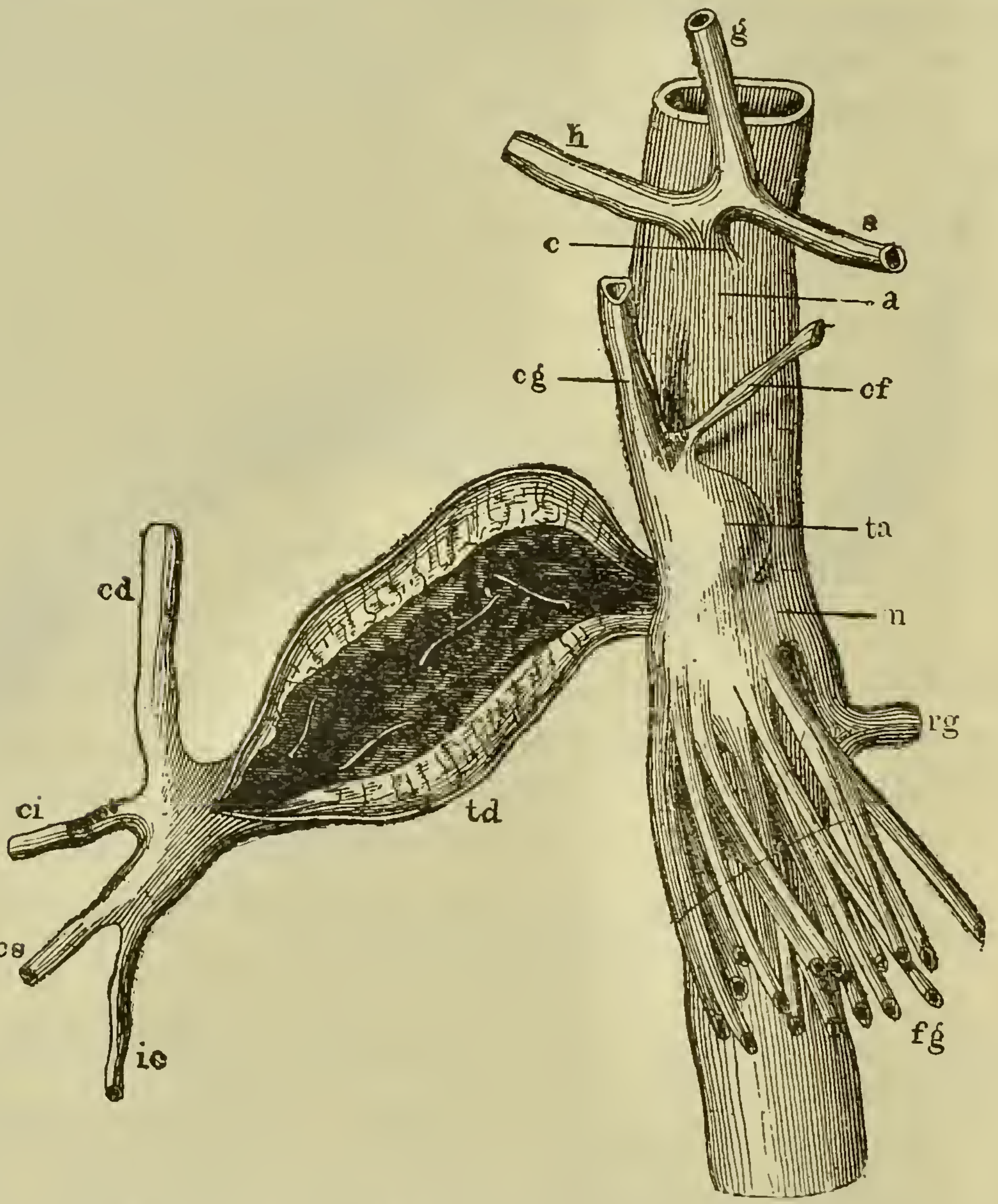

Fig. 24.—Vermiceous Aneurism of Great Mesenteric Artery (½ nat. size). Railliet. (From Neumann.)

a, Aorta ; *c*, cœliac ; *h*, hepatic ; *s*, splenic ; *m*, trunk of great mesenteric ; *ta*, anterior fasciculus with aneurism ; *cg*, left colic ; *cf*, first artery of floating colon ; *fg*, arteries of small intestine ; *td*, right fasciculus with aneurism ; *cd*, right colic ; *rg*, renal ; *ci*, inferior cæcal ; *cs*, superior cæcal arteries.

free in the intestinal contents, where they breed, the ova coming away in the horse's excreta. The red species is by far the most abundant. They are mainly observed in young horses. From investigations during the last few years, it seems that these pests are much on the increase. Fortunately they can be soon checked by the administration of *Thymol* as a nematocide.[1]

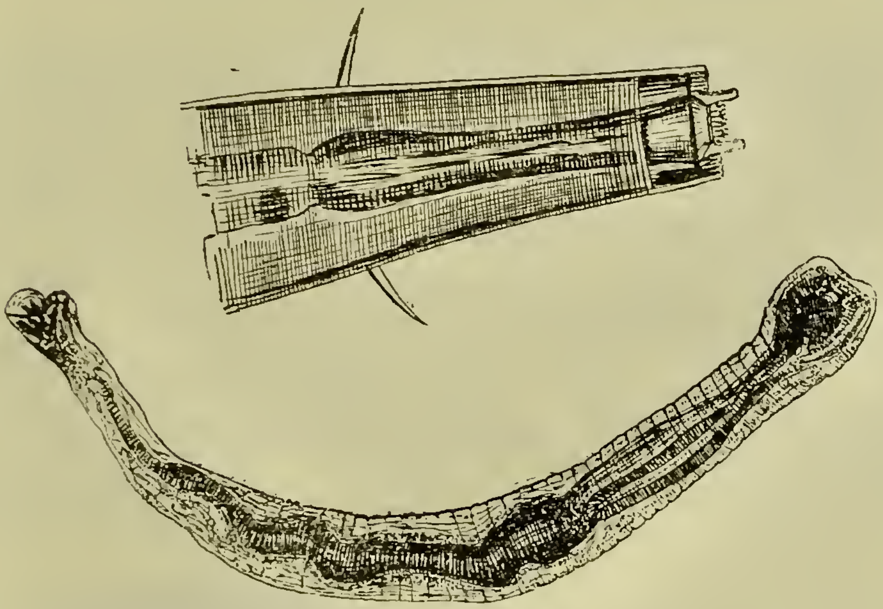

FIG. 25.—SCLEROSTOMUM TETRACANTHUM.
Male (six times nat. size), and enlarged anterior extremity.

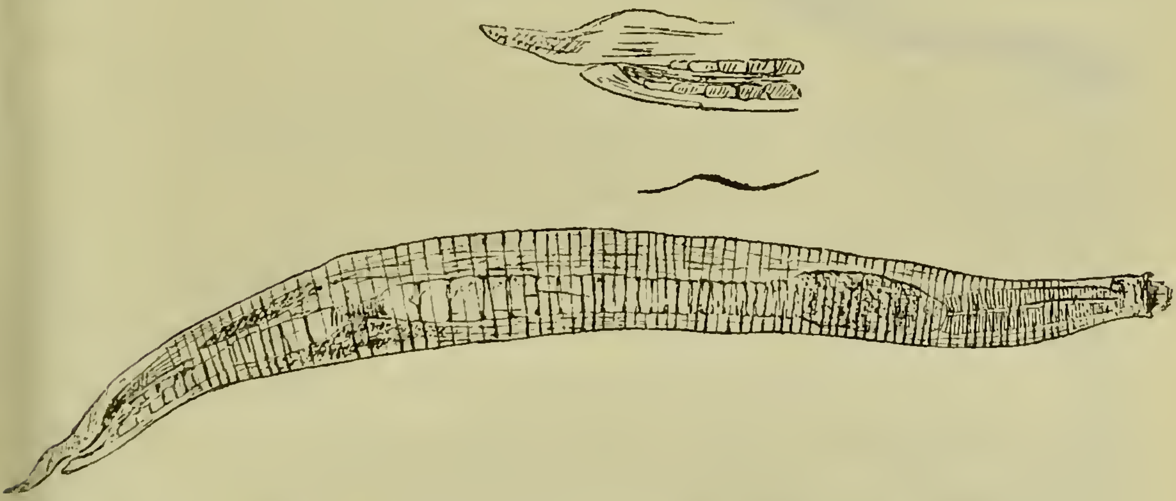

FIG. 26.—SMALL RED SCLEROSTOME (*S. rubrum*) FROM HORSE (female).

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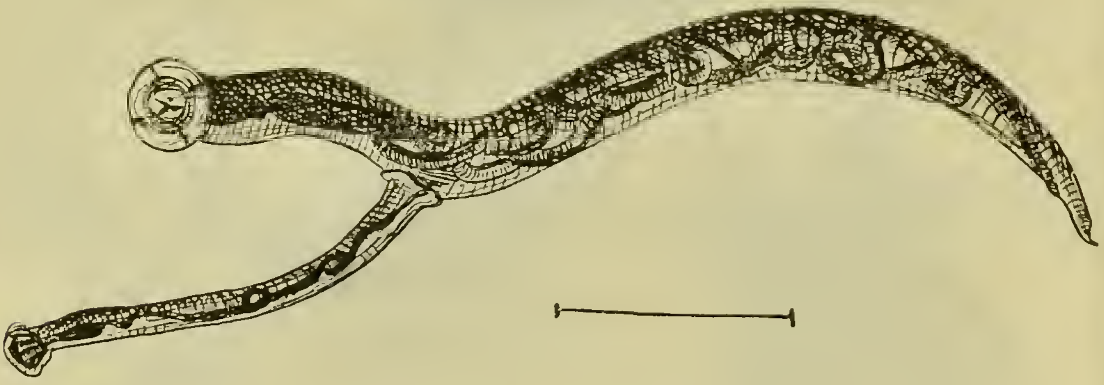
[1] Journal of the S.-E. Agric. Coll., part 6—"An Epizooty produced by species of *Sclerostomum* in Arab Horses," by F. V. T.

The Gape Worm (*Syngamus trachealis*).

Poultry, especially if constantly kept on the same land, often suffer considerable loss from the ravages of a red worm called the "Gape Worm" or "Forked Worm." This nematode lives in the air-passages of fowls, chicks, pheasants, and certain wild birds. On opening the trachea and bronchi of a bird showing symptoms of this disease, we find often as many as twenty red forked worms surrounded by a frothy saliva. The small arm of the fork is the male, which remains almost permanently attached to the female. The former is about one-fifth of an inch long, the latter about four-fifths. They are coughed up by the fowls when they are mature—that is, when full of ova. The eggs escape from the body by its cadaveric decay and lie about upon the ground and in the water, from whence other birds gain the disease. They hatch into small white embryos. Development is direct, no intermediate host being necessary, as has been frequently demonstrated. Their presence can soon be detected by the curious yawning and "gaping" of the host and constant straining forward of the neck. Frequent removal of birds, especially chicks, is the best preventive; whilst fumigation and injection of fluids into the trachea, as mentioned in Appendix I., can be employed as remedies.



Fgi. 27.—Gape Worm (*Syngamus trachealis*).
♂ and ♀ *in copulâ.*

TRICHOTRACHELIDÆ OR WHIP-WORMS.

The Whip-worms are known by having a long, thin, neck-like anterior portion to the body. A small mouth is present at the tip of this long thin region; it is not provided, as in many worms, with lip-like papillæ. They are all small slender worms, with an anus or (in the male) a cloacal opening at the hind end of the body. There is no bursa, as in the Palisade-worms, and one spiculum alone is present.

The two most noteworthy genera are *Trichocephalus* and *Trichinella* (fig. 28).

Trichocephalus is a small worm, with the anterior part of the body much attenuated and whip-like, the posterior part being thick and cylindrical; this latter contains the generative organs, which are coiled in the male. The eggs are curious citron-shaped, hard-shelled bodies, and undergo their development in water. It is found that the Trichocephalidæ require no intermediate host, so that they can be taken direct in drinking water or unclean food.

They do not live free in the gut, but have the whip-like anterior extremity buried in the mucous membrane of the intestine. These worms are found in man, the pig, and the sheep, and cause serious intestinal disturbances. The young worms are hair-like, and resemble very much the trichinæ found in pork.

Another curious form is known as *Trichosomum*, in which the male is very degenerate and lives in the uterus of the female, as many as three or four males being found in one female.

This "degeneration" is a very common phenomenon in parasitic life. Any part of an animal that is not used we find degenerates, and may become lost entirely unless nature utilises it for some other purpose. The second pair of wings in the true flies (*Diptera*) have apparently degenerated, but they are still represented by the so-called "balancers,"—small knob-like processes that are not used now as organs of flight, but as specially modified organs of sense, organs of equilibrium. Very many parasites having no use for limbs, we find are devoid of them (parasitic Isopod Crustacea). One pair of the gill-arches seen in fish, in the higher animals have nearly gone; but they have been saved from total extinction by being converted into structures for a different object—namely, for forming the bony chain in the auditory capsule. Use and disuse increase and decrease respectively the size and development of any part of the animal frame. Perhaps the greatest degeneration is in some of the worms, where the male, as mentioned above, is reduced simply to a *testis*, which lives permanently in the female's body.

The Trichina of Pork (*T. spiralis*).—This small worm produces the often fatal malady *Trichinosis.* The adult sexual worm is found in the intestine of man, the pig, the rat, and in practically all other carnivorous animals. The adult worm is only about one-twelfth of an inch in length. The sexes, as in all Nematodes, are quite distinct, and a true copulation takes place. The result of this union is that a very large number of fertile ova are laid by the female, each female laying, it is said, at least a thousand eggs at one time. The females may live for five or six weeks. We find on examining these worms that to every male there are at least twelve females: we can thus realise the hosts of ova that are laid. Not unusually the female *Trichinella spiralis* produces living young.

The ova soon hatch in the alimentary canal of the host, and the larvæ derived from them commence to lay eggs about six or seven days after their entry. Often by the second day after ingestion the larvæ commence to mature; by the fourth day they become mature. The young worms when they come from the ova are extremely minute cylindrical bodies, only $\frac{1}{250}$th of an inch in length. They soon commence to bore their way through the walls of the intestine and enter the sarcolemma of the muscles, penetrating into the primitive bundles, the substance of which degenerates, whilst a rapid increase of the nuclei may be seen to take place. Sometimes the larvæ are carried along in the blood. At first the young lie straight in the muscles, but in about two weeks they form a kind of citron-shaped capsule in which they coil themselves up (fig. 28, A). This capsule is derived from the degenerating connective tissue of the muscle fibre. Gradually the capsule becomes thickened by the deposition of calcareous matter. One can feel the gritty-like bodies when one cuts a piece of meat full of trichinæ with a knife. The young asexual muscle spirales can remain in this position any length of time. But if the diseased flesh is eaten by a carnivorous animal, the gastric juice dissolves the cyst, and the freed worm becomes sexually mature in the intestines in a few days, the sexual organs (fig. 28, D, *T* and *vd*) having been partly formed whilst in the muscle. Man, by eating this diseased pork, con-

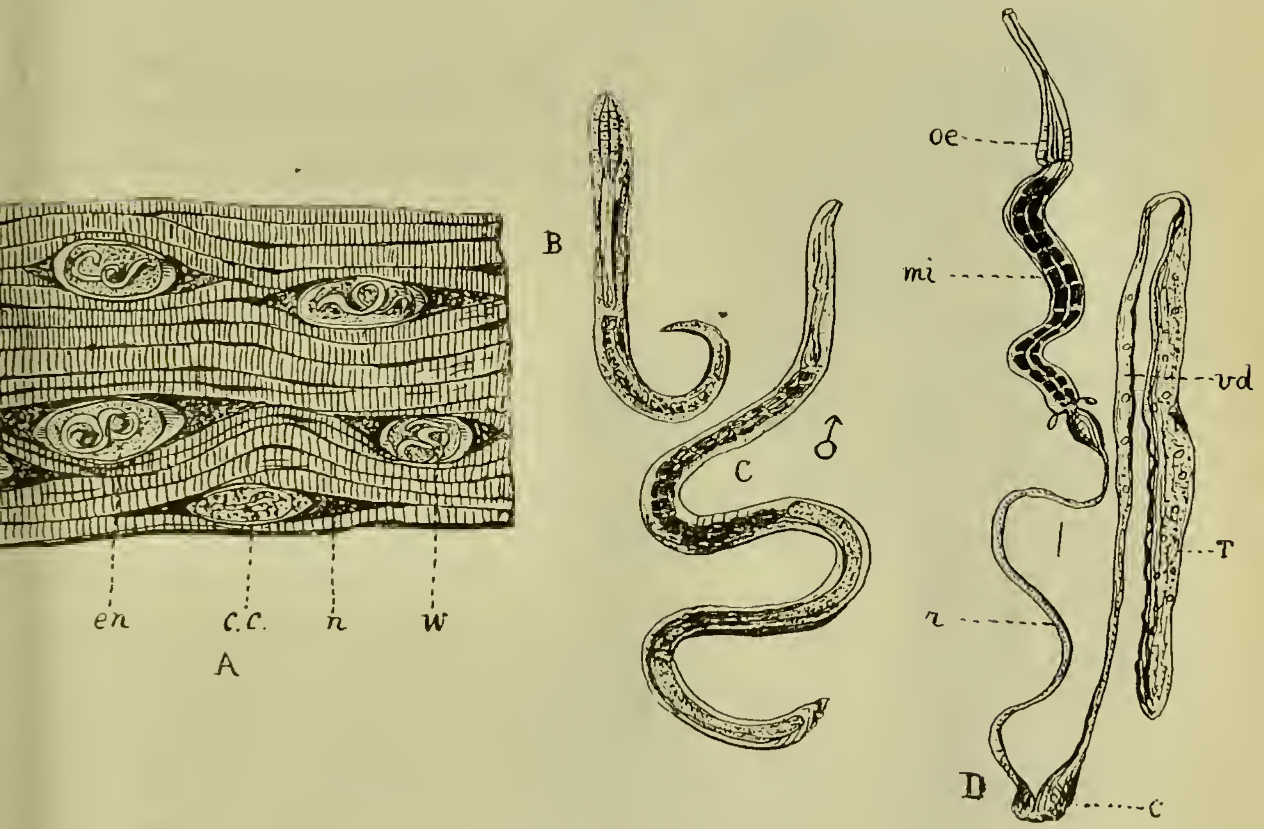


FIG. 28.—TRICHINELLA SPIRALIS.

A, Piece of diseased pork (much enlarged): *en*, cyst; *c.e*, capsule; *w*, encysted worm. B, Larva. C, Male. D, Digestive and sexual organs of ♂ (after Colin): *oe*, œsophagus; *mi*, mid-gut; *r*, rectum; *T*, testis; *vd*, vas deferens; *c*, cloaca.

tracts this dangerous complaint, the worms from the cysts breeding in his intestines and migrating to his muscles. The danger is when the young worms pass through the intestinal walls into the muscle: they, by so doing, produce violent inflammation, which may be fatal, and intense pains result, similar to those occasioned by rheumatism.

The way Trichinosis is said to be partly spread is by the agency of rats. Rats are known to suffer severely from *T. spiralis.* Pigs greedily devour any dead rats they can get hold of, and thus take the disease. How many rats have we seen given to the pigs in farmyards and elsewhere! It is a common practice, and one by which the life-cycle is partly kept going.

Migrations may take place in the rat itself: rats, by eating other dead ones, also keep the worms on the increase, tending of course to the chances of pigs taking the disease, and thus conveying the germs to man. The number of ova produced by one worm is said to be between 10,000 and 15,000.

Eelworms or Anguillulidæ.

Eelworms are free-living Nematodes of small size. Some live in or on plants as parasites, and cause various diseases and abnormal growths in plant tissues. Others live in decaying matter as saprophytes; many may often be found in decaying roots. Fermentations are also produced by some Anguillulidæ, such as by the Vinegar- and Paste-worms. By far the greater number live free in damp earth and in water.

Eelworms are very minute worms, with very thin skins, and lay only a few comparatively large eggs, which undergo rapid development. Parasitic and saprophytic forms can be told by the presence of a curious mouth-spine. This structure, found in the mouth cavity, is very sharp and pointed in front, and can be worked backwards and forwards, so as to penetrate the cell-walls of plants. In all cases an eelworm devoid of a spine is not a plant parasite. The most important genera living in plant-tissues are *Tylenchus*, *Aphelenchus*, and *Heterodera*. The former genus also lives in the earth and in rootage of plants. The genera *Dorylaimus* and *Aphelenchus* also live under similar conditions. *Tylenchus* and *Heterodera* produce the worst diseases.

These undergo part of their life-cycle in the earth and part in their plant host.

The three most typical forms are—(1) the Wheat Eelworm (*Tylenchus scandens*); (2) the Stem Eelworm (*T. devastatrix*); and (3) the Beet Eelworm (*Heterodera schachtii*).

The Wheat Eelworm (*T. scandens* = *T. tritici* of Bastian).

Length about one-twelfth of an inch in the male and one-tenth to one-fifth in the female. These minute white or almost transparent worms are the cause of a disease,

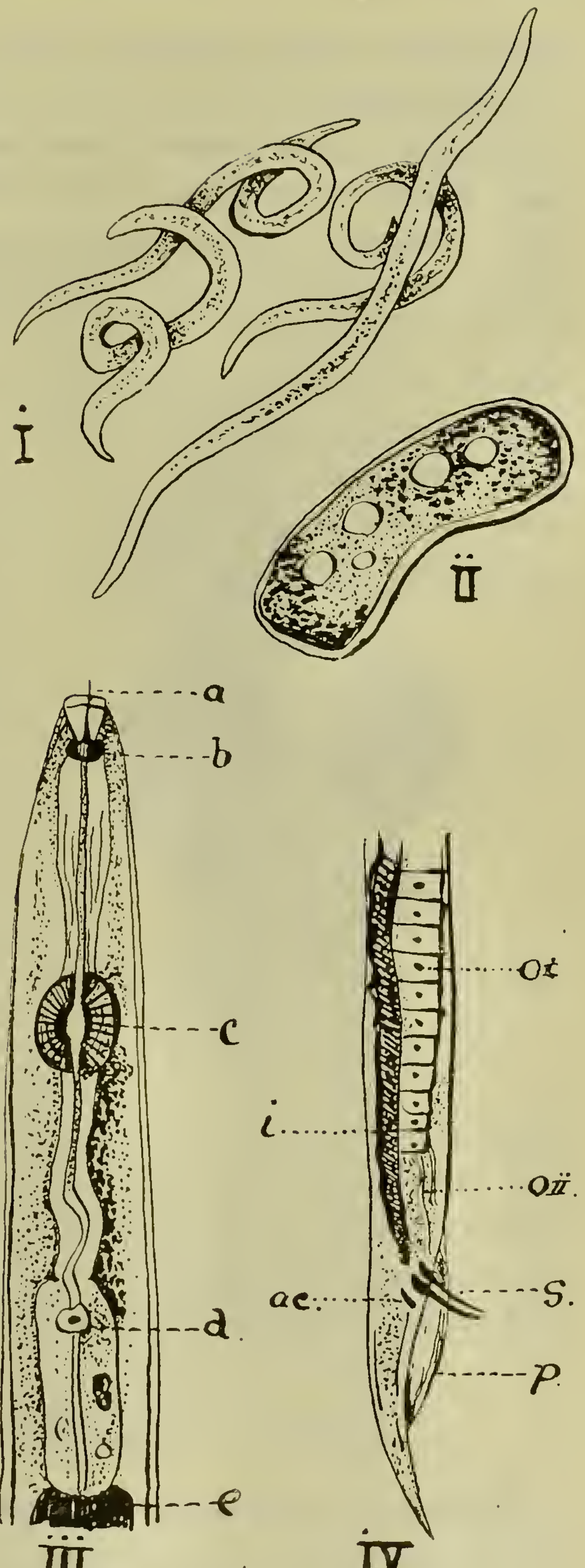


Fig. 29.—Eelworms (*Anguillulidæ*).
i. *Tylenchus devastatrix*, from clover roots; ii. ovum; iii. anterior extremity; iv. posterior extremity of male. (After Ritsema Bos.) Greatly enlarged.

especially in wheat, known as "purples," "ear-cockles," or "peppercorns."

We may often notice in several parts of an ear of wheat that there are in place of the grains dark purplish-brown galls, having a striking resemblance to a seed of the "corn-cockle plant" (fig. 30, A). On cutting open one of these "galls" the interior is seen to be full of a mass of a whitish-yellow colour, which contains thousands of eelworm larvæ, varying from $\frac{1}{30}$th to $\frac{1}{27}$th of an inch long (fig. 30, C). When these galls are re-sown with the wheat-seed, the apparently dried-up worms (E) come to life, and the eelworm larvæ enter the soil. On the sound seeds germinating, the larvæ make their way to the nearest rootlets of the seedling plants, and then bore between the leaf-sheath and the haulm, or in the terminal bud. As the plant grows they ascend, and quickly get into the ear and swell out the ovary (the future grain), whose walls become first dark-green and then purplish-brown. From sixteen to twenty are found in the lowest flower of the ear, ten to twelve in the next, and from four to five in the topmost blossoms. As soon as they enter the flower the worms become sexually mature, and then lay from six hundred to sixteen hundred ova, which give rise to the larvæ we find in the ear-cockle later on in the year.

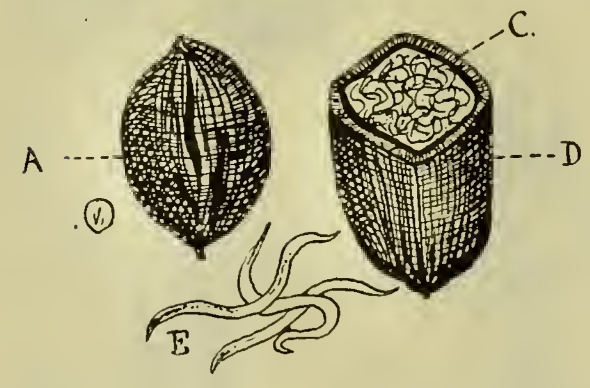


FIG. 30.—EAR-COCKLES IN CORN (*Tylenchus scandens*).

A, galled grain; C, larvæ in cut grain D; E, larvæ. (Greatly enlarged.)

The Stem Eelworm (*Tylenchus devastatrix*).

This small eelworm especially attacks oats, where it produces the disease spoken of as "Tulip Root." It also attacks wheat, oats, onions, hops, and many flowers, and is one of the causes of "clover sickness." Beans and peas also suffer. It works differently in the different plants it feeds upon. The mature worm (fig. 32, 1) is $\frac{1}{25}$th inch long, eel-like in form, and pointed at each end; by means of its piercing mouth-spine it enters the roots and underground stem, making its way up into the tissue.

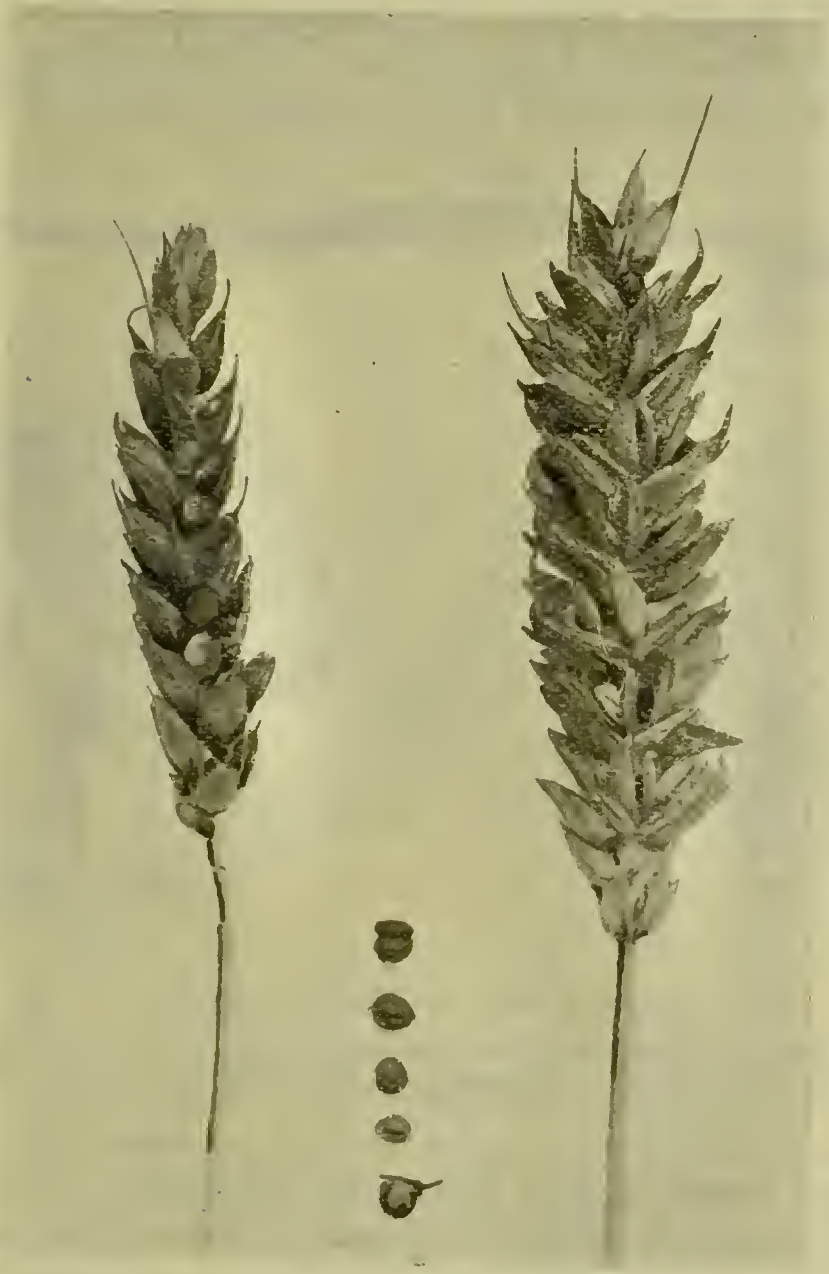


FIG. 31.—WHEAT ATTACKED BY *Tylenchus scandens*, AND GALLED KERNELS.

It is sometimes spoken of as the Stem Eelworm. In oats the parasites cause the stems to become short, swollen, and contorted, and the edges of the leaves are often twisted, giving a tulip-like appearance. Hundreds of acres of oats are frequently destroyed in this way every year. In wheat it may cause the same appearance. Peas and beans are infested in the stems, which decay. Onions also become swollen and contorted. The female produces oval eggs, which occur, together with larvæ and adults, in the plant tissue. The larvæ on hatching are about one-seventh the size of the adults. As they grow they moult their skin. As the plants decay they pass into the soil, where they can remain a long time, even when dried up for some months: moisture resuscitates them. They are also carried in the straw in manure. Spring-sown corn is attacked mostly; autumn-sown seldom suffers. Thus, where this disease is bad, spring-sown corn should be given up. Deep ploughing with a skim-coulter should follow an attack, and such plants as barley grown afterwards. Top-dressings will also sometimes save an attacked crop if given in time.

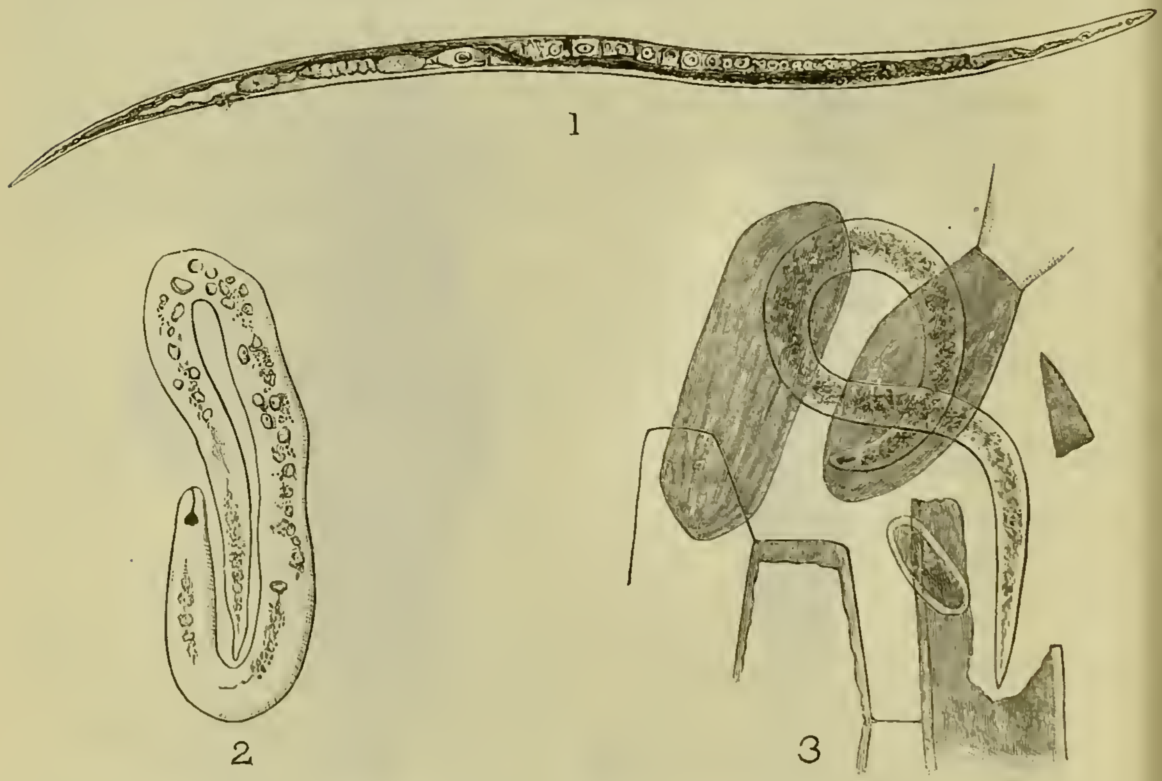


FIG. 32.—THE STEM EELWORM (*Tylenchus devastatrix.* Kühn).

1. Eelworm. 2. Young form just emerged from egg. 3. Eelworm and egg in plant tissues. (1 much magnified, 2 and 3 more highly magnified.)

The Beet Eelworm (*Heterodera schachtii*).

For some time the beet crop on the Continent has been seriously interfered with by a peculiar rotting disease, which has been shown to be due entirely to the working of an eelworm, *Heterodera schachtii.* The female (fig. 33, A) is found fixed to the root and rootlets of the beet, and, unlike most Anguillulidæ, it is citron-shaped, and seldom longer than $\frac{1}{25}$th of an inch : she nevertheless contains as many as three or four hundred ova. The ova when laid are found in groups, being united by a kind of gelatinous sac. The majority of eggs develop inside the female, this process, as a rule, causing her speedy death.

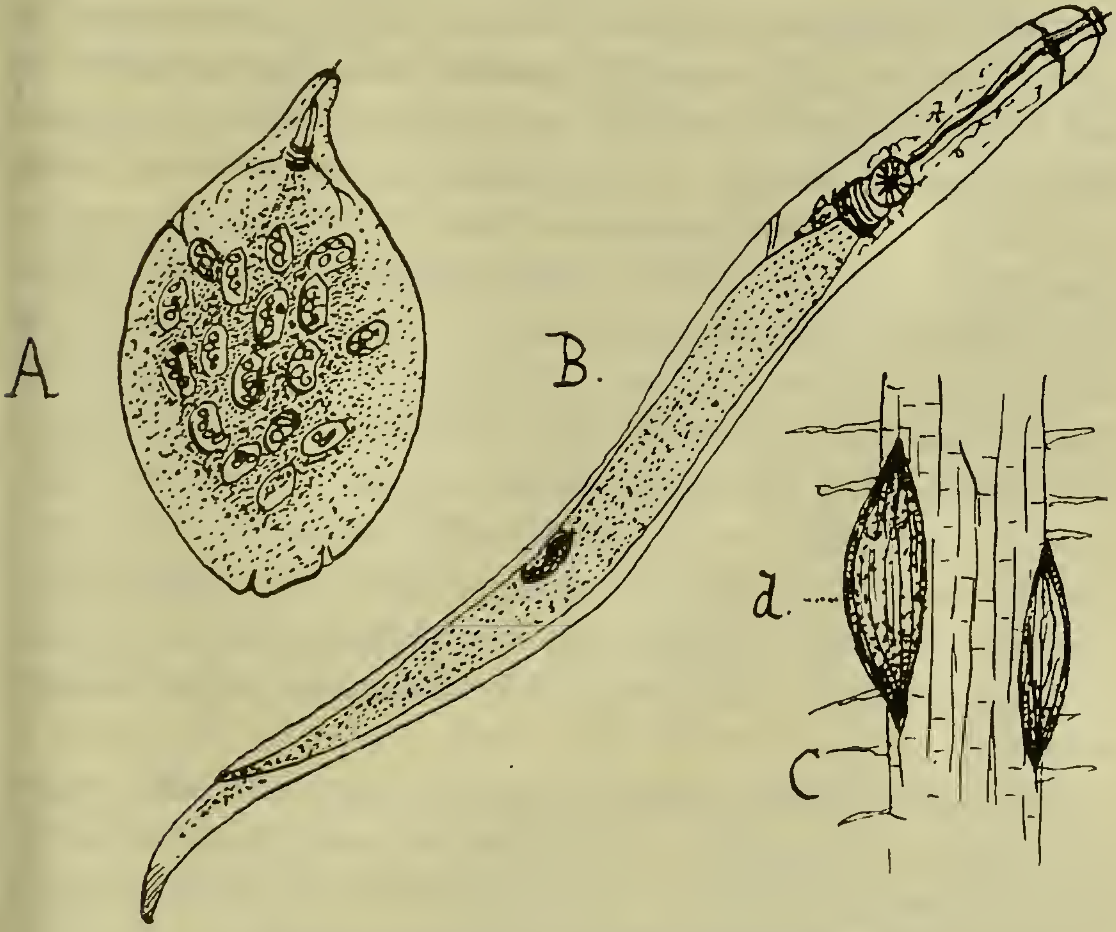


FIG. 33.—THE BEET EELWORM (*Heterodera schachtii*).
A, female ; B, larva ; C, rootlet with galls (*d*). (All greatly enlarged.)

The larvæ when liberated seek out a root of the beet and bore into it, and here they live, causing the disease. When they have entered the root they produce great swellings—"galls," in fact—over their abode (fig. 33, C, *d*). The larva (fig. 33, B) that has thus entered the plant sheds its skin, and instead of being elongated it becomes thicker in shape, ceases to move, and lies with the bulbous patch formed over it. At this time the sexes commence to appear distinct. If the thick motionless larva is to become a male it ceases to feed, shrinks within its old skin, and develops a thin new one, very like the puparium stage of some insects. The newly-formed male worm inside its old skin is more elongate—in fact, it resembles the typical form of an eelworm. When mature this male bores its way out of the root and commences its search for a female. Should the larva become a female, the development is much simplified. The female develops by a simple distension of the body and the formation of the female sexual organs. There is no process of reformation as we observe in the male. When the female is fully formed, the lump on the root ruptures and releases the worm; but she, on the other hand, does not relinquish her hold of the plant, to which she remains permanently attached.

The development from the egg to the adult takes about five weeks. As many as six or even seven generations occur in the year. This same worm attacks hops, producing the disease called "Nettle-head"; it is also found in wheat.

Knot-root Disease in Cucumbers, &c.

"Knot-root" is a disease which affects cucumbers, tomatoes, marrows, &c. It is caused by the eelworm *Heterodera radicicola*, which produces swollen areas and knots of various sizes on the fine and thick roots. The eelworms swarm in these galls, and when the latter decay pass into the soil, which becomes infested with them, ready to attack any fresh plants. This pest has become so bad in tomato-houses, &c., that the soil has frequently to be removed. The soil may also be burnt, and then will remain free for a long time.

ASCARIDÆ AND FILARIDÆ.

The *Ascaridæ* or Round-worms, and the *Filaridæ* or Slender Thread-worms, are found in animals and man in various positions, but especially in the intestine. They are often present in very large numbers, yet seldom cause any serious constitutional disturbance. They are not only found in man, the horse, pig, dog, and cat, but also in many cold-blooded animals.

The *Ascaridæ* are characterised by the following features: Body fairly stout. Mouth triangular, and furnished with three lips with papillæ (fig. 34, F). One is directed towards the dorsal surface, the other two meet together in the ventral line. The male has the end of the body curved, and armed with two spiculæ or sickle-shaped hooks (C).

The *Filaridæ*, on the other hand, may be identified by the following: Body elongated, longer than the Ascarids. Thread-shaped. Six oral papillæ often present; sometimes there is a horny oral capsule. There may be two spiculæ which are unequal or only one, also four præ-anal pairs of papillæ and an unpaired papilla occasionally.

The Ascaridæ all live in the gut of various animals, especially in the small intestine. The Filaridæ take up their abode in the connective tissues.

The most typical Ascarid worm is the large round worm found in the horse, called *Ascaris megalocephala.* It is one of the largest species of the genus *Ascaris.* It is yellowish-white in colour, slightly ridged, and about ten inches long in the ♀ and six in the male. This worm is common in all *Equidæ*, but only affects seriously young animals. They produce colics and digestive disturbances, and sometimes so obstruct the intestine as to cause death. The ova are nearly globular bodies, and are seemingly introduced into the horse in drinking water. *A. suilla* (fig. 34) is often found in the pig. The male is from four to six inches long, the female often as much as eight. It is found in the small intestine, and may produce serious colics.

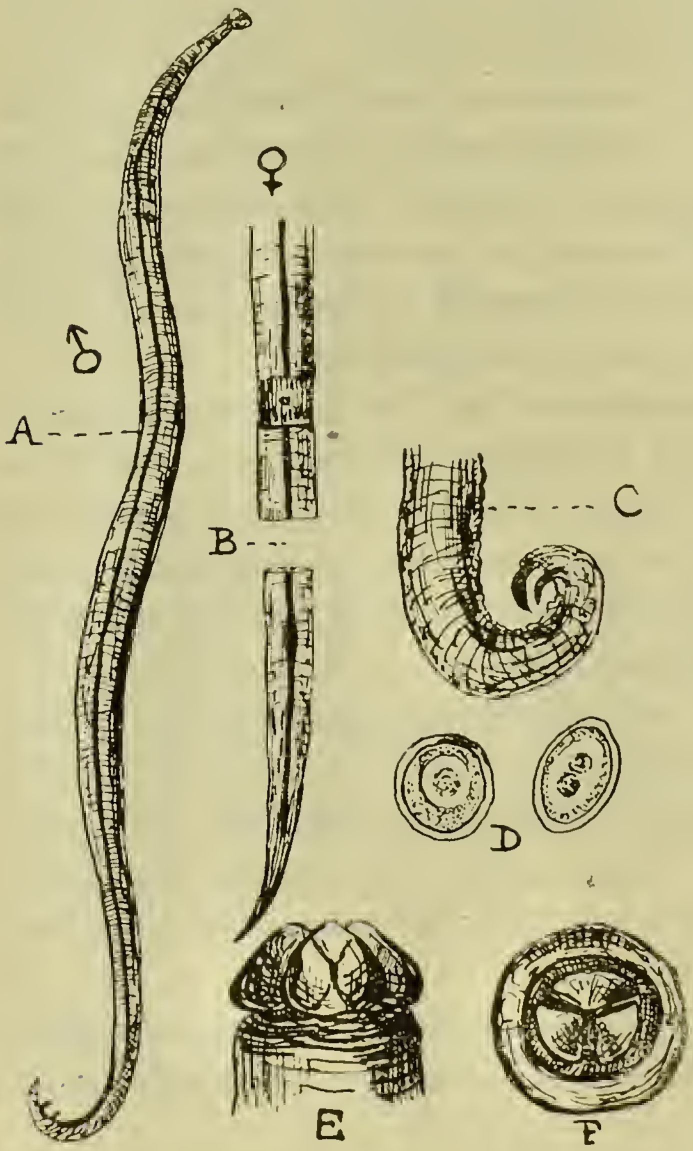


FIG. 34.—ASCARIDÆ.

A, Male *Ascaris suilla;* B, female *Ascaris* (after Railliet); C, caudal extremity, with spiculæ of A; D, ova; E and F, oral papillæ of A.

Another Ascaris, *A. lumbricoides*, is found in the human being.

A common and often troublesome worm in horses is the "Maw-worm": this is one of the *Oxyures*, which may be told by the posterior end of the œsophagus being enlarged into a spherical bulb with a masticatory apparatus. The female is quite unlike the male, having her body long, thin, and pointed towards one end, whilst the other is much enlarged and cylindrical. The male is cylindrical, and has no long tail-like process and only one spiculum. The common Maw-worm is found in the large intestine of the horse and other Equidæ: it is known as *Oxyuris curvula* (fig. 35), and may often be seen hanging from the horse's anus. We have known these worms cause very serious emaciation in horses, but they are easily cleared out by the use of santonin powder. This vermifuge expels many females full of eggs, and immature forms. A long-tailed dimorphic form called *Mastigodes* (fig. 36) has been described by Nitzsch. Males are comparatiuely rare. These worms, I have observed, are passed usually in the morning, generally numbers together, the excreta of the host being full of their ova. Very closely related is the obnoxious little human worm, *O. vermicularis.*

The **Filaridæ** are filiform worms, all of which are found in connective tissue or blood and never in the intestine. A common form in the horse is *Filaria papillosa,* a white worm about six inches long found in the peritoneal cavity. Thousands have been taken out of the thoracic cavity of the horse at one time. They sometimes even penetrate the scrotum. The life-history of this worm, like many others, is quite unknown. Another species, known as *F. immitis,* is found in the heart and pulmonary artery of the dog. Neither, however, occasions sufficient loss to call for further remarks.

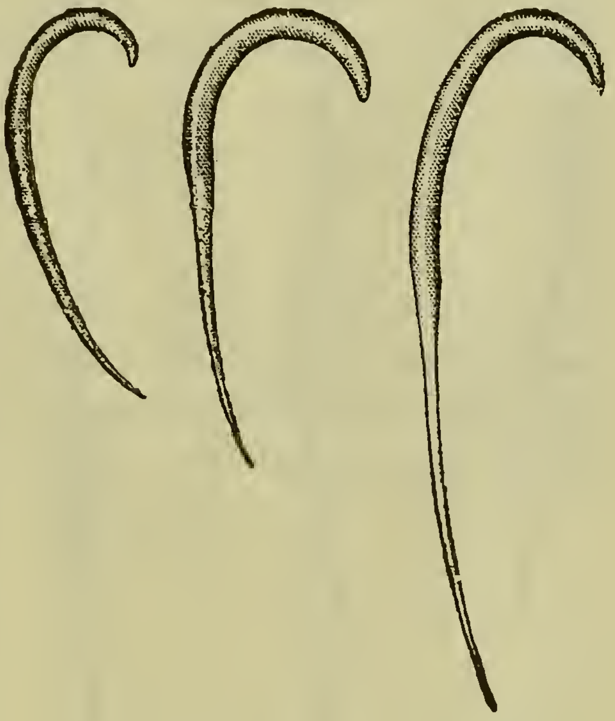


Fig. 35.—Oxyures of Horse.

Females with short tails (=*Curvula*). Railliet. (From Neumann.)

Filaria also are parasitic in man, causing Elephantiasis or Filariasis. These small blood and lymph parasites are carried by mosquitoes (Culicidæ), as is also the *F. immitis* of the dog.

Thymol administered as stated in Appendix I. is certain to free the intestines of Ascarid parasites. For *Filaridæ* it is a matter of prevention.

SUMMARY OF PLATYHELMINTHES AND NEMATHELMINTHES.

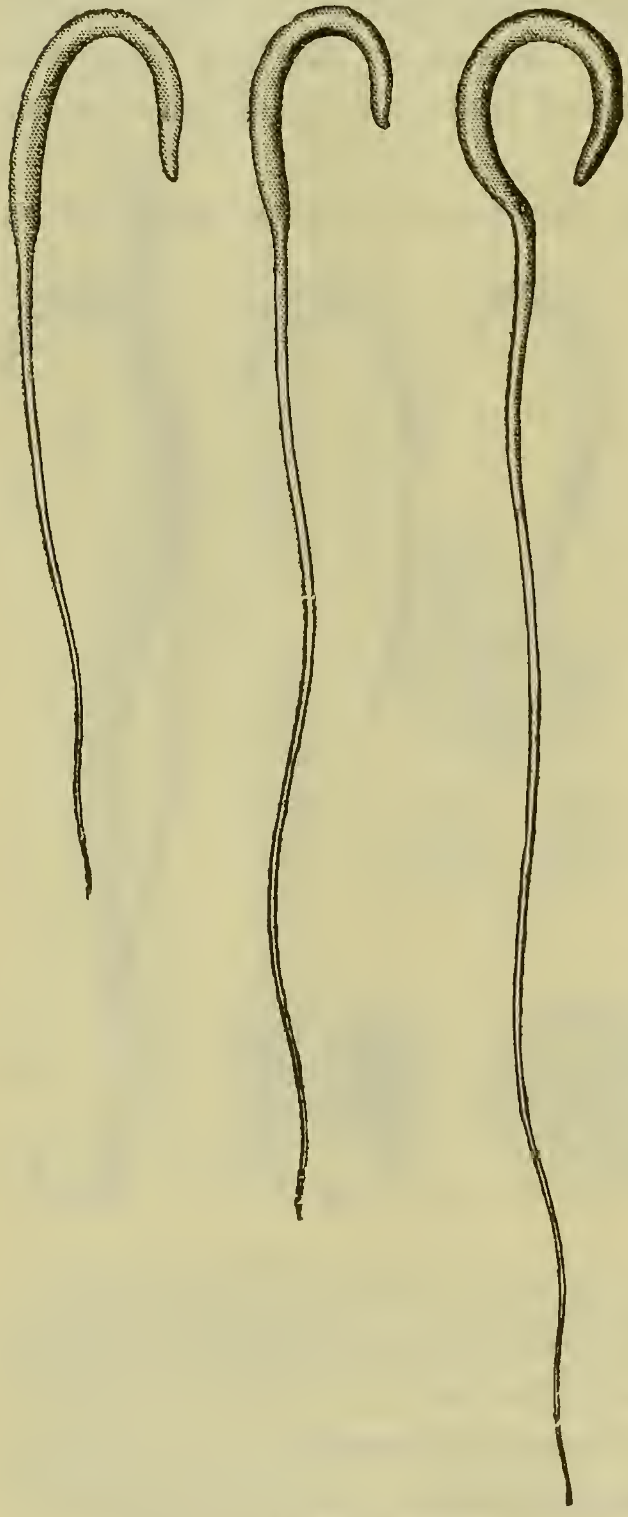


FIG. 36.—OXYURES OF HORSE.

Females with long tails (= *Mastigodes*). (From Neumann.)

Amongst these two divisions of worms we have gone into we must note several important points. First, their parasitic habits, and the often fatal results of this parasitism; secondly, the almost universal rule (except in some Nematodes) of having two distinct hosts during their life-cycle; thirdly, the extraordinary reproduction, often asexual, and the occasional alternation of generations; fourthly, their great vitality, not only in the egg, but also in the larval form; and last, but not least, the great part water plays in their natural history and distribution. In nearly all the worst forms of worms producing animal diseases, the worm passes some part of its life connected with water or in water animals; for instances take the Flukes, Palisade-worms, Gape-worms, Ascarids, Filarias, and even some Cestodes. Thus by paying some attention to what we know of their life-histories, and especially that part of their history in which water plays some part, we may check the deadly results that often happen.

We must also note how one animal becomes infected passively from devouring another. If we know the various hosts we can often stop the attacks by paying attention to these points, as in the "sturdy" of sheep and the "trichinosis" of the pig, by the prevention of canines getting the diseased brains and pigs the infested rats respectively. Dogs kept free from lice (*Trichodectes*) will have none of those bothering and nauseous little tapeworms to contend with; whilst if we could only lessen the water-snails (*Limnæus truncatulus*), or keep our sheep away from them, we should be exempt from the "liver-rot" in our ovine stock.

In regard to ourselves, it is just as important that meat should be cooked well, so as to destroy the "measly cysts" and trichina germs in pork, as well as tend to lessen the chances of contracting that widespread malady *tuberculosis*, and that mosquito larvæ should be killed to prevent "Filariasis."

CHAPTER VI.

WORMS—*Continued.*

CHÆTOPODA AND HIRUDINEA.

OF the segmented worms two groups are of interest to the agriculturist—namely, (i) the Earthworms (*Lumbricidæ*) and Aster-worms (*Enchytræidæ*), and (ii) the Leeches (*Hirudinidæ*): the first are beneficial to the soil; the second are injurious; the last harmful to horses.

Segmented worms have a brain, a circum-æsophageal nerve-ring, a ventral nerve-cord, and a definite vascular system. Generally they are round, but some—such as the Leeches—are flattened ventrally. In form most are cylindrical, with a thick muscular skin. The body is made up of a number of successive segments, constricted off externally. Those segments following the head are similar externally and internally. The tail segments differ, and give origin during the growth of the worm to new segments anteriorly. The internal divisions are called *dissepiments*, and may correspond to the external segmentation, or may equal three, four, or five of the external rings.

These worms are found in all manner of places. The *Chæto-poda* are marine and terrestrial. The marine species live in the sand, on rocks, shells, &c. The terrestrial live in damp earth, and others live in fresh water. They all require damp media to flourish in. Very few are parasitic; those that are so are mainly parasites of plant roots.

Most of these worms are oviparous; a few produce living young; the majority are hermaphrodites, the testes being paired. The development is often direct; the eggs are laid in patches or cocoons, and give origin direct to young worms.

A larval form is, however, found in some marine species (*Chætopoda*) known as Lovén's Larva, whose growth resembles in many respects the growth of a scolex into a Tapeworm.

Segmented worms move by two different processes: (i) by simple or grouped setæ or bristles placed in the cutis, Earthworms, &c. (*Oligochæta*), and (ii) by terminal suckers (*Hirudinea*).

Reproduction may be asexual, by fission and by gemmation in the long axis (*Chætopoda*). As a rule, it is sexual, when the worms may be hermaphrodites (*Oligochæta*, *Hirudinea*) or of separate sexes (*Marine Chætopoda*). The food very largely consists of animal matter; at other times, as in the Earthworms, of decaying vegetation.

Earthworms (Lumbrici).

The Earthworms belong to the Chætopod group *Oligochætæ*, which are characterised by being terrestrial, having no parapodia, but setæ as organs of locomotion; no oral armature, cirri, tentacles, or branchiæ. They are hermaphrodites, and develop direct.

The Oligochætæ are again divided into (*a*) the *Terricolæ*, or true earthworms, with nephridia in the genital segments; and (*b*) the *Limicolæ*, or water-worms, which have no nephridia in the genital segments (*Naidæ*).

Life-history of the Earthworm (*Lumbricus terrestris*).—The eggs of the earthworm are laid in heaps or capsules in the ground. In one or two weeks these white transparent eggs give rise direct to young Lumbrici, which are at first soft, but as they grow they obtain a compact skin armed with setæ in simple pits and have red blood. Eyes are never present, yet worms are very susceptible to light. Each capsule is filled by several ova, plus the sperm from the male receptacle. As a rule, only one ovum, or a very few at least, develop; the others die and shrivel up, unless eaten, as they often are, by the embryo that hatches out. This embryo eats not only the others, but it takes up all the common mass of albumen. It then bursts its way out of the capsule as a perfect worm, minus its sexual organs. Earthworms grow by fresh segments being added posteriorly. The mature female organs are two ovaries in the thirteenth segment and two oviducts in the same, commencing in two ciliated funnels and opening to the exterior in the fourteenth segment. On the ninth and tenth segments are two pairs of sperm-reservoirs, the receptacula seminis, which open between the ninth and tenth and tenth and eleventh segments. These are full of sperm during copulation.

The male organs consist of two pairs of testes in the tenth and eleventh segments, opening by an aperture on the fifteenth. In the anterior half of the worm, over these sexual organs, is formed in the breeding season a swollen band called the *clitellus*. Earthworms, although hermaphrodites, copulate: this act takes place at night on the surface of the earth in June and July to the greatest extent. The worms apply themselves ventrally to one another, and lie in opposite directions, so that the opening of the receptaculum seminalis of one worm is opposite the clitellus of the other. During copulation the sperm flows back along a longitudinal groove to the receptaculum of the other worm. The ova produced as the result of the fertilisation undergo unequal segmentation.

Earthworms live most of their time underground, burrowing to a great depth, often down to the subsoil: by so doing they let in moisture and air, and loosen the subsoil to a considerable extent, thereby doing much good. They draw down into their burrows numerous leaves and other vegetation, which they devour in large quantities: they feed upon these leaves during the daytime, and draw them down at night. We may often see them partly protruding from the opening of their burrows. Large quantities of earth are also eaten by these useful annelids, which they pass out of their tunnels on to the surface as the "casts" or worm-casts we see so abundantly on our lawns, &c., at certain times. By so doing these annelids are constantly bringing fresh soil to the surface, sometimes from a considerable depth, and thus do immense good. To the workings of earthworms the soil called *humus* is partly due, by the repeated outpouring of their casts and the intermixed leaves that they are constantly drawing down, and which soon become decayed. Humus is a dark rich soil which covers the surface of the land. According to Darwin, every year as much as ten tons of soil are passed through their bodies and brought to the surface by them per acre. Worms prepare the soil for seedlings of all kinds by exposing the mould to the air, and by sifting out the large stones. Bones and *débris* are buried under their castings, and, decaying, mix with the dead leaves, &c., that they draw beneath the soil, thus augmenting its fertility.

Aster and Plant Root Worms (*Enchytrœidæ*).

Some of these worms are plant parasites — the so-called *Enchytrœidæ*—which live in the soil and attack the roots of plants. They are small worms, usually white in colour, and can be told by the setæ being arranged in rayed groups, not singly as in Lumbricus.

Hirudinea (Leeches).

The last group of worms to examine are the Leeches. Leeches are provided with a ventral sucker for attachment to their host. They are all hermaphrodites, and parasitic during some time of their life, but are chiefly ecto-parasites. The body of the leech is ringed, but the outside annulations do not correspond to the internal divisions. There may be two suckers, one round the mouth, the other ventral. The oral aperture is composed of three slit-like openings, in each of which is a serrated jaw.

Life-history of Leeches.—The ova are fertilised in the worm. Prior to depositing their ova the worms anchor themselves upon a stone or plant, or in the case of the medical leech leave the water and burrow into damp earth and mud. At this time the genital rings get much enlarged by the swelling of the genital glands, and the cells in the skin, of a glandular nature. When the time to oviposit comes the leech tightens its hold of the plant or object on which it is fixed; it then moves about with much violence and covers the front of its body, especially the genital rings, with a viscid mass, which hardens and produces a fine membrane. When this membrane is complete the leech passes out a number of ova and an albuminoid mass, and at once withdraws its body from the barrel-shaped capsule, which is left behind as a kind of cocoon full of eggs, each loose end closing up and forming a safe shelter for the ova, of which there are only a few in each cocoon. From these ova young leeches appear, of the same form and appearance as the adult, but not sexually mature. Most leeches live in water or in damp earth. They move by a series of loops with the help of their suckers, and also by swimming. Many are parasites on the gills and skin of aquatic animals, such as fish and crayfish; others are only occasionally parasitic on the skin of warm-blooded animals. When young they live upon snails, insects, frogs, &c., but when mature they seem to require the blood of the warm-blooded animals for nourishment.

THE HORSE-LEECH (*Hæmopis sanguisuga*).

The horse-leech has an elongated body contracted in front, widest in the middle, and with a sucker at each extremity. It is composed of from 95 to 100 rings. They copulate much as described in the case of the earthworms. There is also a girdle or sexual band produced. The ova are laid about forty days after fecundation. When ovipositing, this leech, like the Medical Leech (*H. medicinalis*), burrows into damp ground and lays about fifteen ova in the funnel-shaped case secreted by the girdle. This case is left by the worm, and hardens and forms a brown spongy cocoon. Each leech may form two of these cocoons. The ova take from twenty to thirty days to incubate. The young leeches are filiform, and remain near the case for some days, using it as a kind of shelter.

This species attacks horses as they come to drink, each individual withdrawing as much as one and a half drachm of blood from the wound they make with their mouth. Often one may see blood flowing from the wound after the leech has fallen off its victim, gorged with food. There is some fluid in the pharynx which prevents the blood from coagulating in the leech. This feast will last the worm for a year. Leeches are long-lived animals, not maturing until four or five years old, and live for as much as twenty years. They inhabit ponds, ditches, and springs, and flourish on the bottom mud. The young seem to be very partial to running water. This horse-leech is met with over most of Europe and in North Africa, and is extremely troublesome to horses in Syria. It does not live on the skin, but enters the mouth, nose, &c., of horses as they are drinking, and seizes hold of the mucous mem-

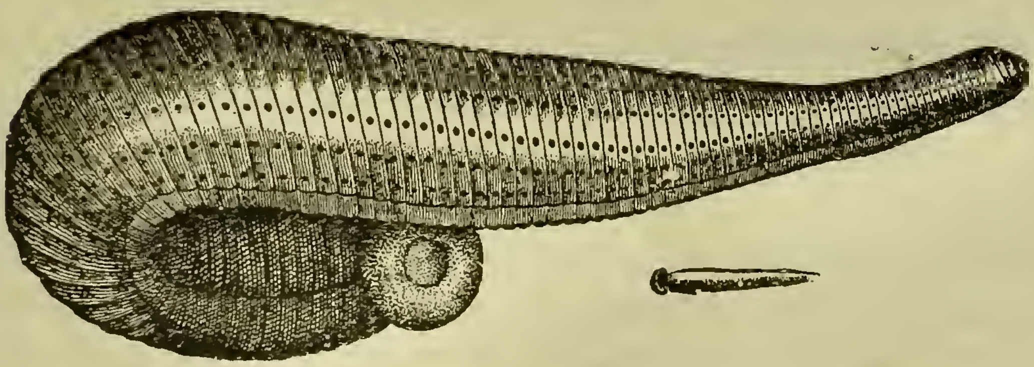


FIG. 37.—THE HORSE-LEECH (*Hæmopis sanguisuga*). Railliet. Natural size, and young leech. (From Neumann, Par. Dis. Ani.)

brane, which it lacerates. They have been found in the mouth, pharynx, nasal fossæ, larynx, and vagina. So much blood is sometimes withdrawn that the animals are killed.

The Medical Leech (*H. medicinalis*) used to be applied very plentifully for bleeding, but now is seldom employed in this country for that purpose. It is still bred in large numbers in ponds in France, where it is fed by putting old horses into the ponds, upon which they ravenously feed and soon kill.

Land-leeches also occur in some regions, especially Ceylon. Tennent, in his account of the island, tells us that he has seen blood flowing over the edge of Europeans' shoes from their innumerable bites. In England leeches are seldom troublesome to any great extent.

CHAPTER VII.

ARTHROPODA OR JOINTED-LIMBED ANIMALS.

More is known of this group of animals than of those we have been dealing with in the last three chapters. This is due to their more pleasing and interesting, if too often injurious, habits. One seldom meets with a collector of the innumerable worms, whilst, on the other hand, the jointed-limbed animals have hosts of devotees in all parts of the world, especially those sections of them—such as the brilliant and elegant Butterflies and Moths and Beetles—which make a considerable show when captured and placed in a cabinet. Yet there are several of the Arthropod groups which meet with little attention, and these particular groups, although inconspicuous, are of the greatest interest and importance to the agriculturist and horticulturist.

Arthropods are invertebrate animals which are bilaterally symmetrical, and which have their bodies divided up into a number of rings, called segments or somites, some or all of these segments bearing ventrally one or more pairs of jointed appendages. The Arthropoda have an external skeleton formed by the skin becoming hardened from the deposit of a substance known as chitin. All this class of invertebrates are provided with a distinct alimentary canal, nervous system, and reproductive organs. Respiration takes place in a variety of ways: the whole body surface may be respiratory (*Acarina*), true pulmonary sacs may be present (*Araneida*), or a specially modified system of respiratory tubes known as *Tracheæ* may be elaborated (Hexapoda, &c.); whilst the *Crustacea* or Crabs, Lobsters, Wood-lice, &c., are provided with branchiæ or gills. Development may or may not be direct. Spiders (*Araneida*) are very similar to the adult when first hatched. Hexapoda and many Crustacea develop by means of a metamorphosis or transformation: the young insect on hatching from the egg is totally unlike the adult or imago, and is known as the *larva.* The larval stage may give rise to a second condition, the pupa or chrysalis, in some insects. The changes from the larva to the imago or adult take place partly by a series of moults or ecdyses—the old skin of the insect rupturing and then releasing the larva, which has prior to its moult formed a new and soft skin, capable of distension, beneath. This enables the internal organs to swell out, and thus growth takes place. During this ecdysis the entire exoskeleton is cast, even the chitinous covering of the eyes and feelers. Growth also takes place between these "moultings," for there is a soft space between each segment or somite which enables the entire abdominal region to stretch. There are in some insects, however, more complicated changes than those mentioned here. A complete remodelling of the larval body takes place in the pupal state, whereby the larva is metamorphosed into the imago by a process called *Histolysis.* Sense-organs are well developed in most arthropods: organs of vision are represented by two kinds of eyes,—simple eyes or ocelli, and compound or facetted eyes, complex ocular structures peculiar to the jointed-limbed animals. The senses of hearing, taste, and smell are also strongly developed, the antennæ or feelers being probably the most important structures in connection with hearing and smell, although the palpi probably have some such function. In conjunction with these we find a highly developed brain, at least for invertebrate animals, and a central nervous system consisting of a ventral nerve-cord and a pair of ganglia in each segment. Considerable variations take place in the latter: numbers of ganglia may amalgamate, as seen in some flies (*Diptera*), or may remain separate, as in many Orthoptera (*Cockroaches*).

There is great variation in form and in habits of these various jointed-limbed animals, which can be enumerated as each group is taken. That they are of much economic importance to the farmer, gardener, and stock-keeper is needless to state. Insects and mites are accountable for endless loss to the farmer, fruit-grower, and gardener. Mites (*Acarina*) not only devastate our fruit and hops, but are the cause of such wasting diseases as "scab," mange, and various other acariasic diseases in stock; whilst even the aquatic Crustacea have amongst their vast concourse of species some, such as the Wood-louse and Crayfish, which have a terrestrial life and have become injurious to mankind. We must not be led away, nevertheless, with the idea that all Arthropods are our enemies, and so ruthlessly destroy them: many are of infinite help to us as agents for keeping down and destroying those that do us harm, whilst such insignificant creatures as the Coccidæ produce not only cochineal but also sealing-wax, shell-lac, and other products. The Silkworm and the Bee alone make up for the many deficiencies of insect life.

The Arthropods are divided into four sections, namely—

1. *Crustacea* (Crabs, Lobsters, Shrimps, &c.)
2. *Araneida* (Spiders, Mites, Scorpions, &c.)
3. *Myriapoda* (Centipedes, &c.)
4. *Hexapoda* (Insects).

The Crustacea and the Hexapoda have the Arthropod characters most clearly defined, and we will take one of the latter group to point out the peculiarities and general structure of the Jointed-limbed Invertebrates.

For this purpose we cannot choose a better example than the Cockroach (*Periplaneta americana*), which can be easily obtained, as our type. This species, although not so universal as the common Cockroach, the so-called Black-Beetle of our kitchens (*Blatta orientalis*), offers better scope for dissection, being much larger. It may be obtained in numbers from any of our docks, and is often present in such hordes on board ship as to be a great nuisance.

THE COCKROACH.

The whole insect will be observed at first sight to be covered with a chitinous exoskeleton, which is thick and hard, dark

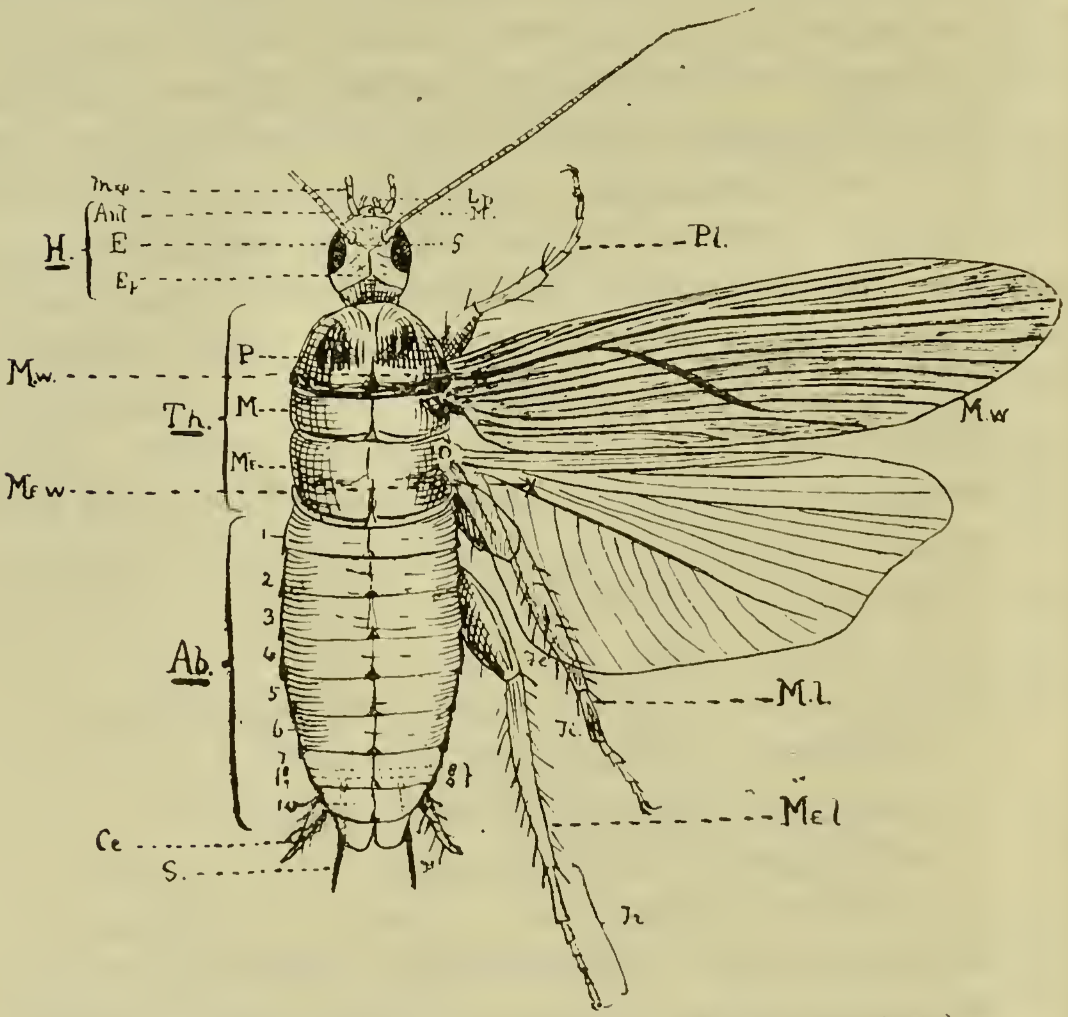


FIG. 38.—STRUCTURE OF AN ARTHROPOD (*Periplaneta americana*).

H, head; *Th*, thorax; *Ab*, abdomen; *Mxp*, maxillary palps; *Lp*, labial palps; *M*, maxillæ; *Ant*, antennæ; *E*, eyes; *Ep*, epicranium; *f*, fenestræ; *P*, prothorax; *M*, mesothorax; *Me*, metathorax; *Ce*, cerci; *S*, styles; *Mw* and *Mew*, meso- and metathoracic wings; *Pl*, *M.l*, and *Me.l*, legs; *Fe*, femur; *Ti*, tibia; *Tr*, tarsus; 1-10, abdominal segments.

brown in colour, but paler and softer between the somites. The body of the cockroach is divided up into a number of rings or segments, which are movable upon one another except those of the head, which are firmly fused together. This segmentation of the exoskeleton is seen, internally, in the muscular and nervous systems.

On examining the cockroach (fig. 38), which belongs to an order of Hexapoda known as the *Orthoptera*, we shall at once notice that the whole body is divided into three parts—the head (*H*), the thorax or chest region (*Th*), and the abdomen (*Ab*). The head is loosely connected with the thorax by a narrow isthmus of tissue, the neck. The head is broad, and the mouth, which bears biting jaws, is on the lower portion. The jaws will easily be seen to work sideways or transversely, and not vertically as ours do. Situated on the head are two large, black, reniform elevations, the *eyes* (*E*), one on each side. These are the compound eyes, each being composed of a number of hexagonal facets. Situated at the inner side of the bases of the feelers or antennæ are two small white patches, the so-called *fenestræ* (fig. 38, *f*, and fig. 39 A, *F*). The antennæ or jointed feelers spring from the base of the eyes in a depression on their anterior edge. The dorsal and posterior surface of the head is called the *epicranium* (*Ep*). Below the

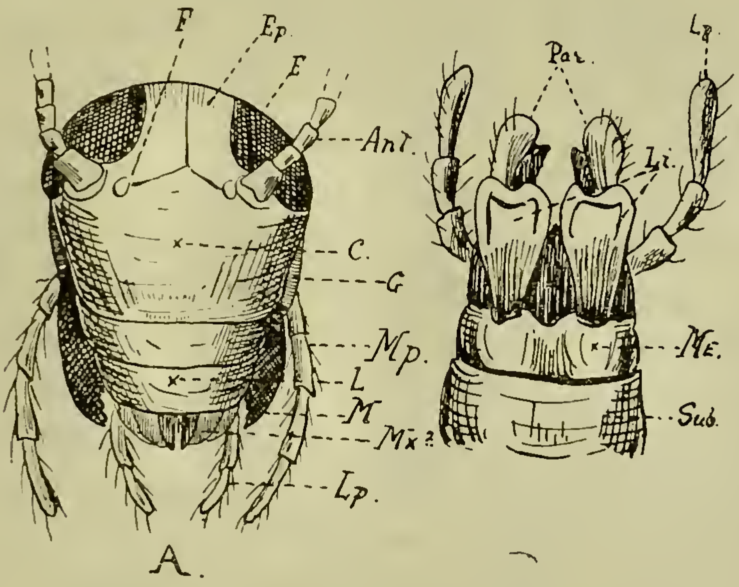


FIG. 39.—A, HEAD, AND B, LOWER LIP OF COCKROACH.

epicranium comes the *clypeus* (fig. 39 A, *c*), a broad plate, which is followed by a smaller plate united to the front of the clypeus, called the *labrum* or "upper lip" (*L*). The plate on each side below and behind the eyes is called the *gena* or cheek (*G*). Ocelli are absent in this type, otherwise they would be situated on the epicranium. The *thorax* is composed of three segments, united by sutures. Each segment is known respectively as the pro-, meso-, and metathorax (fig. 38, *Th*). Each ring is composed of an upper plate, the notum or tergum, and a lower plate, the sternum, so that in the thorax we have pronotum, meso-, and metanotum above, and the pro-, meso-, and metasterna below. The spaces between the nota- and sterna are covered by chitinous plates, called the pleuræ. The *pronotum*, the upper portion, is prolonged over the neck. The mesonotum, which is smaller than the pronotum, bears a pair of leathery wings. These wing-covers are movably united to the tergum or *mesonotum*. The metanotum also bears a pair of thinner wings, the true organs of flight. If we are examining *Blatta orientalis* we shall not observe these in the female, nor the second pair of wings.

The *abdomen* (*Ab*) is flattened dorso-ventrally. It is composed of ten distinct somites, the hinder ones being invisible, as they are pushed into the anterior ones. The upper parts of the segments are called *terga* (fig. 42, *T*). Of the ten, only eight can normally be seen, the eighth and ninth being hidden under the seventh. Situated at the side of the posterior ventral anus are a pair of small plates called the *podical plates*. It is said that these represent an eleventh segment. They can easily be observed by raising the tenth tergum. On the tenth tergum are a pair of jointed processes called *cerci* (fig. 38, *Ce*). In the male a pair of styles are also borne on the ninth sternum (*S*). The *sterna* are the ventral plates, the equivalents of the terga. The seventh in the female bears a process passing backwards, forming part of the large genital pouch.

Appendages of the head.—On the head are placed the antennæ and the mouth. The latter opens behind the labrum and between the jaws. The two antennæ arise from two oval membranous patches below the eyes and just in front of them. The mouth is of that type known as the biting mouth. It consists of a pair of stout jaws, toothed on the inner margins, the *mandibles* (fig. 39 A, *M*). These jaws are present in all biting arthropods. The first *maxillæ* follow the mandibles behind. Each maxilla consists of three chief or primary parts—(i) the *protopodite;* (ii) *endopodite;* (iii) *exopodite.* The first will be seen to consist of two joints, the cardo or proximal joint and the stipes or distal joint. The second, or endopodite, has also two parts, the inner portion or *lacinia* being blade-like, the outer or *galea* soft. The exopodite, usually called the *maxillary palp* (*Mp*), is a five-jointed process, carried on the outer side of the distal end of the stipes.

The *second maxillæ* (fig. 39 B) are very like the first, but small, and are fused together, forming a plate in the middle line, the *labium* or lower lip. The structure of this lower lip is easily seen in this insect. The two basal parts of the protopodites are fused in the middle line, forming a two-jointed plate, the larger one being called the *submentum* (*Sub*), the smaller and distal one the *mentum* (*Me*). The latter bears endo- and exopodites. The endopodites together are known as the *lingua* (*Li*). The exopodites are three-jointed palps (*Lp*).

Thoracic appendages.—On the thorax are three pairs of legs attached to the sterna, and two pairs of wings united or articulating with the meso- and metanota.

Each leg is made up of five divisions as follows: the *coxa* (fig. 40, *a*), a stout, proximal, leaf-like segment, uniting the leg to the body; then follows a small segment called the *trochanter* (*b*), which unites at its distal end with the *femur* (*c*), which in turn is followed by a slender straight segment armed with spines, the *tibia* (*d*). The last division, the *tarsus* or foot (*g*), is constituted of six segments in this type (Cockroach), the last tarsal bearing a pair of claws or *ungues* (*h*). The number of tarsals vary in different groups of Arthropods. The first tarsal is sometimes spoken of as the metatarsal (*f*).

Abdominal appendages are seldom found in Hexapods: when present, they are never in the form of locomotory organs as they are in Crustacea and Myriapoda. In our type we see only the anal cerci before mentioned. The *anus* is situated beneath the tenth abdominal tergum and between the podical plates.

The *spiracles* (fig. 42, *Sp*), or breathing pores, are at the sides of the thorax and abdomen; they are twenty in number. On the thorax one pair will be seen between the pro- and mesothorax, another between the meso- and metathorax, and others on each side of the first eight abdominal segments. They are in the form of slit-like oval openings, with branched processes running across them.

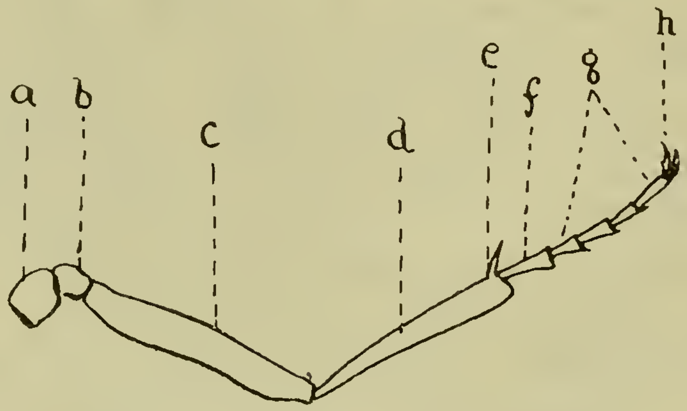


Fig. 40.—Structure of Insect Leg.

a, Coxa; *b*, trochanter; *c*, femur; *d*, tibia; *c*, tibial spur; *f*, metatarsus; *g*, tarsus; *h*, ungues.

(Six foot segments occur in the Cockroach.)

Internal Anatomy of the Cockroach.

By dissecting the cockroach under water we can gather a fair knowledge of the general anatomy of an arthropod with considerable ease. On removing the chitinous covering of the thorax and abdomen very carefully, there will be exposed a straight chambered tube running along the middle line of the thorax and abdomen. This is the so-called insect *heart*. Lateral slit-like openings along the sides of this organ are called the *ostia*, through which the blood returns to the heart, to be pumped out afresh to the body through the opening in front by a rhythmical contraction of the walls of the tube. There are no blood-vessels as in higher animals; the blood is poured into the body cavity, and there bathes the organs and comes in contact with the respiratory tubes.

An opaque-white mass of fat, the *fat-body*, surrounds, or nearly so, the abdomen.

The *digestive organs* can be easily unravelled, so that each part is distinctly visible. The alimentary tube is short, and convoluted in the hinder parts. The first portion is lodged in the head, and is called the *buccal cavity*, into which open two glands, one on each side, the *salivary glands* (*Sg*), by a single salivary duct (*Sd*) in a median aperture. Then follows a narrow gullet or *œsophagus* (*Oes*), which gives rise to a sack which is situated in the thorax and part of the abdomen, the *crop* (*P*). The crop is thin-walled; but the next division, the *gizzard* (*G*) or stomach, has hard muscular walls and contains six large teeth. These alimentary parts are known as the *stomatodæum*, being formed by an anterior invagination in the embryo. The stomatodæum has a chitinous lining continuous with the chitinous cuticle of the head. Following the gizzard will be observed a short thin tube, which forms a connection between the original anterior and posterior invaginations of the embryo. It is called

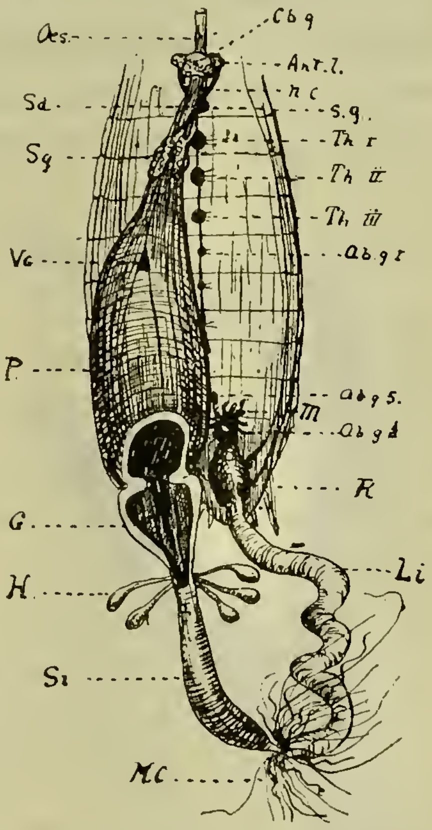


FIG. 41.—DIGESTIVE ORGANS OF THE COCKROACH.

Oes, Œsophagus; *Sd*, salivary duct; *Sg*, salivary glands; *P*, proventriculus; *G*, gizzard; *H*, hepatic cæca: *Mc*, Malpighian tubes; *Li*, large intestine; *Si*, mesenteron; *R*, rectum; *M*, anal gland; *Cb.g*, cerebral ganglia; *S.g*, sub-œsophageal ganglion; *n.c*, nerve-collar; *Th.* i to *Ab.g* 6, ganglia.

the mesenteron (*Si*). The hinder parts of the canal are composed of the small and large intestines and rectum. The proximal end of the short small intestine or ileum is marked by the attachment of a number of fine glandular tubes known as *Malpighian tubules* (*Mc*), which are probably excretory organs. The *colon* or large intestine (*Li*) is wide and long, and terminates in a short dilated terminal part, the rectum (*R*). At the anterior end of the mesenteron will be seen seven convoluted club-shaped diverticula called *hepatic cæca* (*H*). (Five only are represented in fig. 41.)

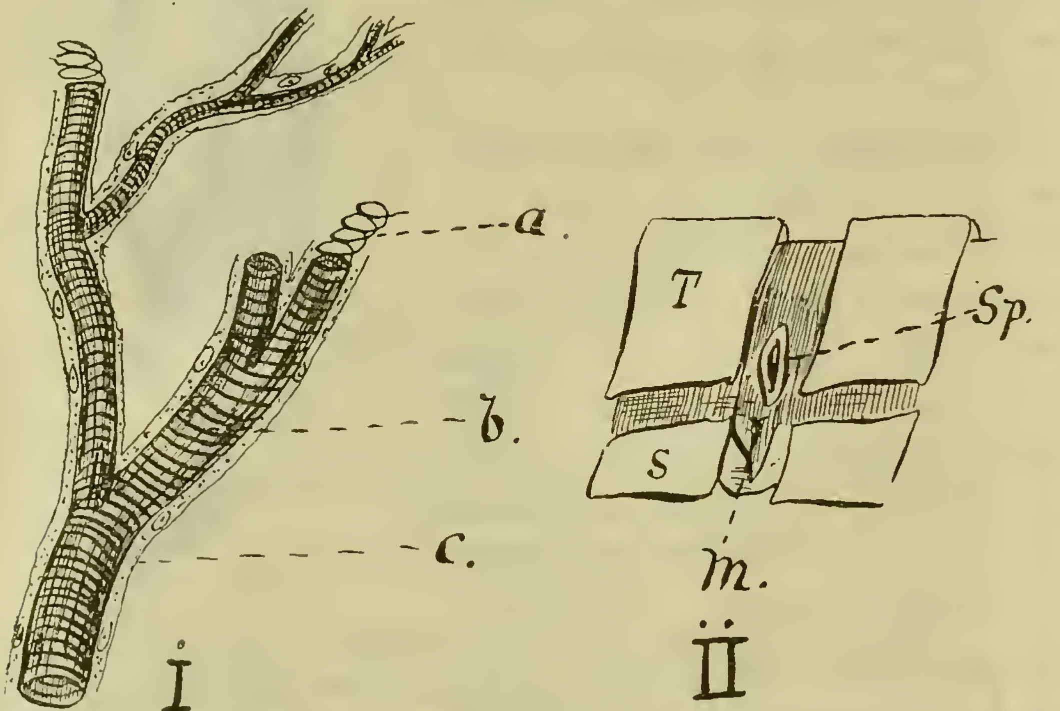


FIG. 42.—i, TRACHEA, AND ii, SIDE-VIEW OF PART OF ABDOMEN, showing spiracle (*Sp*). *T*, Tergum ; *S*, sternum ; *a*, spiral fibre ; *b*, inner coat ; *c*, outer coat.

The *Respiratory System* consists of a series of tubes containing air. This can be easily demonstrated by plunging the opened cockroach under water, when the tubes will be shown as silvery threads, due to the air contained in them. These air-tubes or *tracheæ* (fig. 42, i) commence at the spiracles and run to all parts of the body. When minutely examined the tracheæ will be seen to be circumscribed by a dark spiral band (*a*). Respiration takes place by these tubes, carrying the air to all parts of the body and its organs, hence blood-vessels are not so necessary as when one definite area only is for respiratory functions, as in the lungs of a vertebrate animal. In the former case the air goes as it were to the blood ; in the latter the blood goes to the air. Exspiration takes place by the muscles of the body contracting and so compressing the tracheal tubes ; inspiration by the elastic recoil of the walls of the tubes.

The *Reproductive System* consists in the male of *testes*, *vasa deferentia*, *vesiculæ seminales*, and *ejaculatory duct*. Unlike the worm, a single pair of testes only exist, embedded in the fat below the fifth and sixth segments of the abdomen. They can only be seen in a young cockroach. The tubes leading from the testes to the vesiculæ seminales are the *vasa deferentia*, one on each side. The vesiculæ form two tufts of white glands which hold the spermatozoa, and which open into the anterior part of the ejaculatory duct. The female organs consist of *ovaries*, which are two sets of long tubular organs in the hind end of the abdomen. Each ovary is composed of eight tubules, uniting to form a single oviduct on each side. In each tubule the ova may be seen in different stages of growth. The oviducts unite before opening to the exterior into a single tube. There is also a body called the *spermatheca*, which opens by a median aperture on the ninth sternum, consisting of two small unequal cæca. Close behind the opening of the spermatheca are two other apertures, those of the *collaterial glands*, much branched and convoluted tubular organs. Externally will be seen six strong processes definitely arranged on the ventral surface between the vulva and anus, used as aids to deposit the ova (= female genitalia). The male has a number of hooks and plates forming an external copulatory organ, the equivalent of the female processes, but asymmetrically disposed.

The *Nervous System* (fig. 43), which can be exposed by removing the fat-body and organs, consists of a *supra-œsophageal* (*a*) and a *sub-œsophageal* ganglion (*c*) united by commissures, forming an œsophageal "nerve-collar" (*b*) around the gullet in the head. Running down the ventral surface of the thorax and abdomen is the ventral nerve-cord, which is double. This chain is swollen out into a pair of ganglia united by commissures in each of the three thoracic segments (fig. 43, *d*, 3-5), and a pair in the first six abdominal segments. There is also a *visceral* nervous system (fig. 41, *Ve*).

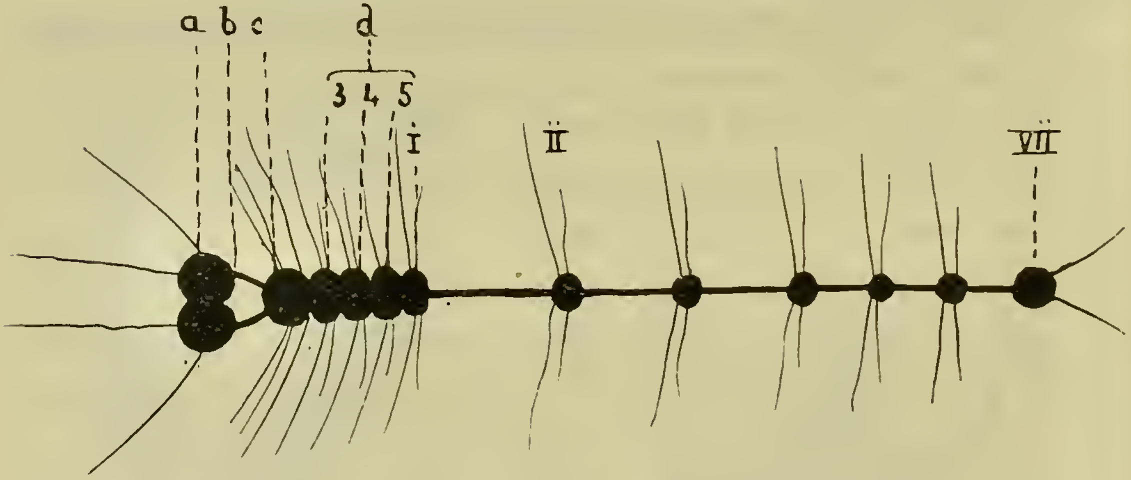


Fig. 43.—Nervous System.

a, Supra-œsophageal ganglion ; *b*, nerve-collar ; *c*, sub-œsophageal ganglion ; *d*, 3-5, thoracic ganglia ; i.-vii., abdominal ganglia.

Characters of the four Groups of Arthropods.

The following are the distinctive features of the four divisions of the jointed-limbed animals :—

1. *Crustacea*—This is the group that includes the Lobsters, Crabs, Shrimps, Prawns, Crayfish, Wood-lice, &c. They are nearly all water-breathing Arthropods, respiring by means of branchiæ or gills. There are always two pairs of antennæ and compound or facetted eyes. On the abdomen are organs of locomotion.
2. *Arachnoidea*—These are the Spiders, Red Spiders, Scab Mites, and Scorpions. Respiration is various : some respire by lungs, others by tracheæ, yet others by the whole body surface. The head and thorax are always united into one piece, the cephalothorax, and in some (Mites) the abdomen is also united to the cephalothorax. Antennæ are never present. There are always four pairs of legs (except in Eriophyidæ), which are never carried by the abdomen. Eyes never compound, ocelli only present.

3. *Myriapoda*—Centipedes and Millipedes. Head quite separate from the body, but no distinction between thorax and abdomen visible. One pair of antennæ. Abdomen composed of many segments. Legs very numerous, always more than eight pairs. Tracheal respiration.
4. *Hexapoda*—Head, thorax, and abdomen distinct. One pair of antennæ. Eyes both simple and compound. Legs always six in number. No appendages of locomotion on the abdomen. Two pairs of wings generally present. Respiration tracheal.

Crustacea.

The Crustacea are chiefly aquatic arthropods. Some few species live in damp earth and in damp general surroundings (Wood-lice and Crawfish). The Wood-lice belong to the order *Isopoda:* they may be told by the equal and symmetrical feet or legs, whilst in the others, such as the Crab and Lobster, the claws are asymmetrical. There are three species injurious to horticulturists in Europe, all of which belong to the family *Oniscidæ.* The Oniscidæ belong to the second tribe of Isopoda, called the Euisopoda, which have the body made up of seven free thoracic segments and the same number of paired appendages. The abdominal feet are so modified as to form branchial lamellæ. The Oniscids or Wood-lice (fig. 44) are land Isopods, with the endopodites of the abdominal feet formed into branchiæ, the exopodites into protective lateral plates on the outside. Peculiar modifications may be seen on the two front abdominal feet, which are provided with special sacs to contain air. The three common species are *Oniscus asellus* of Linnæus, *Porcellio scaber* of Latreille, and *Armadillidium vulgaris* of Linnæus (fig. 44, A). They are popularly called Monkey-peas or Slaters in Britain, the Cow-bugs of America; perhaps the term Wood-louse is that most usually employed.

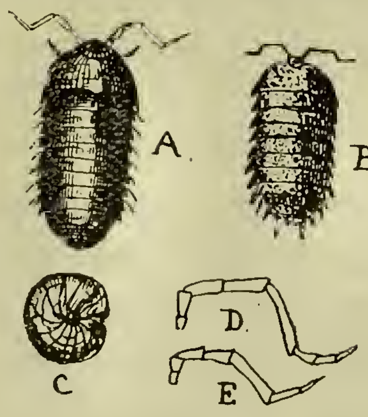


Fig. 44.—Wood-lice.

A, Armadillidium vulgaris; B, Porcellio scaber; C, A. vulgaris; D, antenna of Oniscus; E, antenna of Porcellio.

Oniscus asellus is omnivorous, eating animal and vegetable refuse. The Onisci thus act as scavengers; but they also eat fruit, seedlings, and mushrooms, which they seriously damage, especially the soft fruits, as peaches, nectarines, and melons. Greenhouse and hothouse plants suffer severely from their ravages, as also do strawberry plants, the wood-lice eating away at the roots and around the crowns. They conceal themselves in damp dark places, under stones and suchlike, and in crevices in walls. Rotten woodwork is very often filled with them. The eggs, which are numerous, are carried in a pouch in the thorax, the young wood-lice remaining close to the parent for some time. This grey species cannot roll itself up, as we find is commonly done by many of the other species, whilst it can also be told by the antennæ being eight-jointed (fig. 44, D), instead of seven as in *Porcellio* and *Armadillidium* (E). *Armadillidium vulgaris* (A) is larger, smoother, and of a uniform slaty-blue, and always rolls up into a ball at the least stimulus (C). *Porcellio scaber* (B), with the seven-jointed antennæ, is brown and much varied in colour, and with a rough shell and two longish anal spines. There are many species in this genus, but the above are the commonest. All the Wood-lice can be easily trapped by placing pieces of potato or scooped-out apples about. Pots filled with moss and horse-dung invariably attract large numbers, when they can be seen in the day-time and killed. The only poisons I can find to kill them are mercury bicyanide and Voss's phospho-nicotyl.

Crawfish as Crop Destroyers.

In some restricted localities in the south of the United States a crawfish or crayfish does considerable damage. In the Houston clay lands of Mississippi and Alabama certain areas are so infested by these crustacea that it is almost impossible to raise any crop with profit. The soil they infest is very wet, even in dry seasons several feet of water remain in the tunnels. They attack cotton and corn, and do most damage to the young plants. Large fields of cotton have been eaten in a single night. They tear away the tender cotyledons and carry them to their burrows, and also tear off the leaves. In badly infested land from 8000 to 12,000 holes may be found to the acre. The females produce from 50 to 400 eggs, according to age. The ova develop in a month, and the young remain with the parent for one or two weeks. They are solitary in habits. A few drops of carbon bisulphide put in each hole was found to kill them in a few hours.

Chloride of lime at the rate of one ounce (of the strength of one pound to three gallons of water) put in each hole also kills them. They should also be killed by mechanical means. Ground and mixed with meal they form an excellent egg-producing food for chickens. (*Vide* Year-book of the Department of Agriculture, U.S.A., 1911, pp. 321-324. A. K. Fisher.)

MYRIAPODA.

The myriapods are divided into two groups—namely, Centipedes or *Chilopoda* and Millepedes or *Chilognatha.* The former have the mouth provided with foot-jaws, and have one pair of jointed feet on each segment. The latter have imperforate mandibles, adapted for ordinary biting and chewing. The first three segments have one pair of feet on each, the remainder two pairs. The feet will be seen to be terminated in a single claw. Eyes may or may not be present: when present they are in the form of clusters of ocelli. The jaws of the Millepedes are like those of the cockroach; but in the Centipedes the jaws are formed out of the forelegs, each with a hollow tube perforating the jaw, which is connected with a poison-gland on each side at the base.

The Centipedes are carnivorous in habit, and thus friends to the agriculturist, whilst the Millepedes or vegetable feeders are noxious. The latter are known as False-wireworm.

Young Myriapoda are composed of a few segments only, and with six legs on the anterior segments; they grow by the addition of new segments posteriorly, and cast their skin a number of times until they become sexually mature. The chief families in the Chilognatha are the *Glomeridæ*, *Blanjulidæ*, *Polydesmidæ*, and *Iulidæ* or "snake millepedes." *Glomeris* resembles in appearance and habits the wood-louse. The most destructive are those of the genera *Blanjulus*, *Iulus*, and *Polydesmus*. *Blanjulus pulchellus* (fig. 45, A) is one of the most harmful species, and is extremely common. It is nearly half an inch in length, slender, about the thickness of a fair-sized pin; it is pale pinkish-yellow in colour, with a double row of bright crimson or purple spots on it. It is found in roots, and especially amongst the scales of lilies, which it causes to decay, as well as in most other plants. The young have only a few segments and three pairs of legs, which appear on the second, third, and fifth segments. After repeated moulting they reach maturity, when they are composed of about fifty segments. Like Iulidæ they live upon decaying vegetation and sound plant tissue, and are also said to feed on slugs, snails, worms, and insects. This latter, however, I cannot verify by experience. Two other species are common—namely, the large black *Iulus terrestris* (Linn.), with a pointed tail, and the very similar *Iulus Londinensis* (fig. 45, B), which has a round tail. Both feed upon the rootage of various plants.

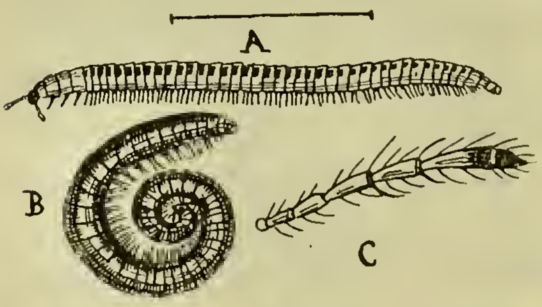


FIG. 45.—MILLEPEDES.

A, *Blanjulus pulchellus*; B, *Iulus Londinensis*; C, antenna of *I. terrestris*.

Iulus breed in May, June, and July. The female forms a nest in the earth for her eggs, usually some distance below the surface: the nest is a hollow sphere, smooth inside, rough outside, and a small opening is left at the top. The size varies from that of a filbert to cob-nut. The eggs, to the number of about a hundred, are laid through the hole; they are small and covered with a gummy fluid. Then the hole is closed up, and in twelve days the ova hatch.

The genus **Polydesmus** forms a link between the two groups of Myriapods. The species are flat and compressed, instead of being rounded as in Iulus. The nest is the same and the young develop as in Iulus, but the legs are on the second, fourth, and fifth segments in the young specimens. *Polydesmus complanatus* (fig. 46, 2), a pale purplish-white or rosy-tinted species, nearly an inch in length when mature, has similar habits to Iulus, feeding especially upon onions, and often causing their decay. I have received notice of much damage caused by them in greenhouses.

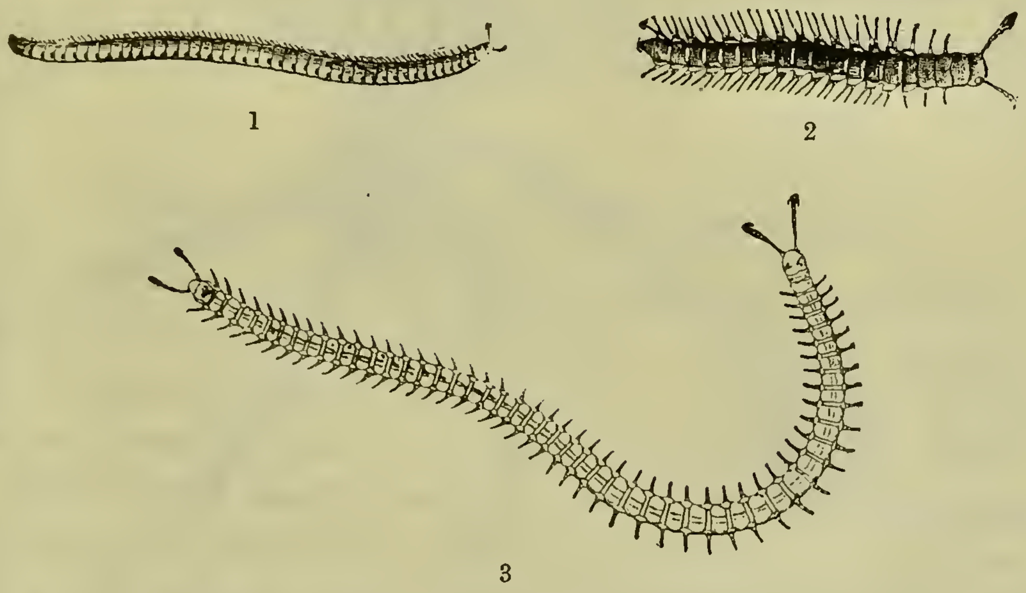


Fig. 46.—Millepedes (1, *Blanjulus pulchellus*; 2, *Polydesmus complanatus*). Centipede (3, *Geophilus subterraneus*). All slightly enlarged.

The **Chilopoda** or Centipedes (fig. 46, 3) are all beneficial. They are represented by four families in England (*Lithobiidæ*, *Scolopendridæ*, *Notophilidæ*, and *Geophilidæ*), all being more or less abundant. One of the commonest British species is *Geophilus longicornis* of Leach, which is a long, yellowish, thread-like creature, often two inches in length. It moves rapidly, with a curious, sinuous, snake-like movement. The male spins a web and deposits in the middle a single spermatophore, and the female comes to the web to be fertilised. The eggs are laid in a little cell in the earth, and are looked after by the female, who is said never to leave them for the two weeks they are incubating, coiling herself round them in the cell. This species may often be turned up in the earth whilst digging in a garden, when by its great activity it soon will bury itself again. Their food is composed of other ground-insects, snails, slugs, and small worms. Some species are luminous.

Lithobius breeds later than Iulus, going on until August. The female rolls the viscid eggs on the soil and so coats them with earth. The male, if he sees the ova, at once devours them.

ARACHNOIDEA (*Spiders, Scorpions, and Mites*).

The three chief groups of the Arachnoidea are the Spiders, Scorpions, and Mites. The first and last only are of any agricultural importance. Another small division known as the *Pentastomidæ* must also claim a few passing words, as they sometimes cause ill effects and loss in farm stock, living as parasites in the sinus of the bones and air-sacs of animals and birds. The distinguishing feature of the Arachnoidea is the presence of four pairs of legs, which are nearly always found in the adult. There is no true metamorphosis; but growth takes place by a series of ecdyses, the young resembling the adult in general form. The ova develop rapidly. The three divisions are characterised as follows:—

i. *Araneida* or Spiders (fig. 47, A) have the head and thorax united into one piece, the cephalothorax (*c*), the abdomen (*a*) being distinct. Eyes are represented by clusters of ocelli (fig. 47, B, *f*).

ii. *Scorpionidæ* have the anterior palpi elongated like legs, and provided with nippers like the claws of a crab. The abdomen may have the last six segments elongated and formed into a spurious tail.

iii. *Acarina* or Mites (fig. 49) are characterised by having the head, thorax, and abdomen all fused into one piece, and the legs either eight or four in number.

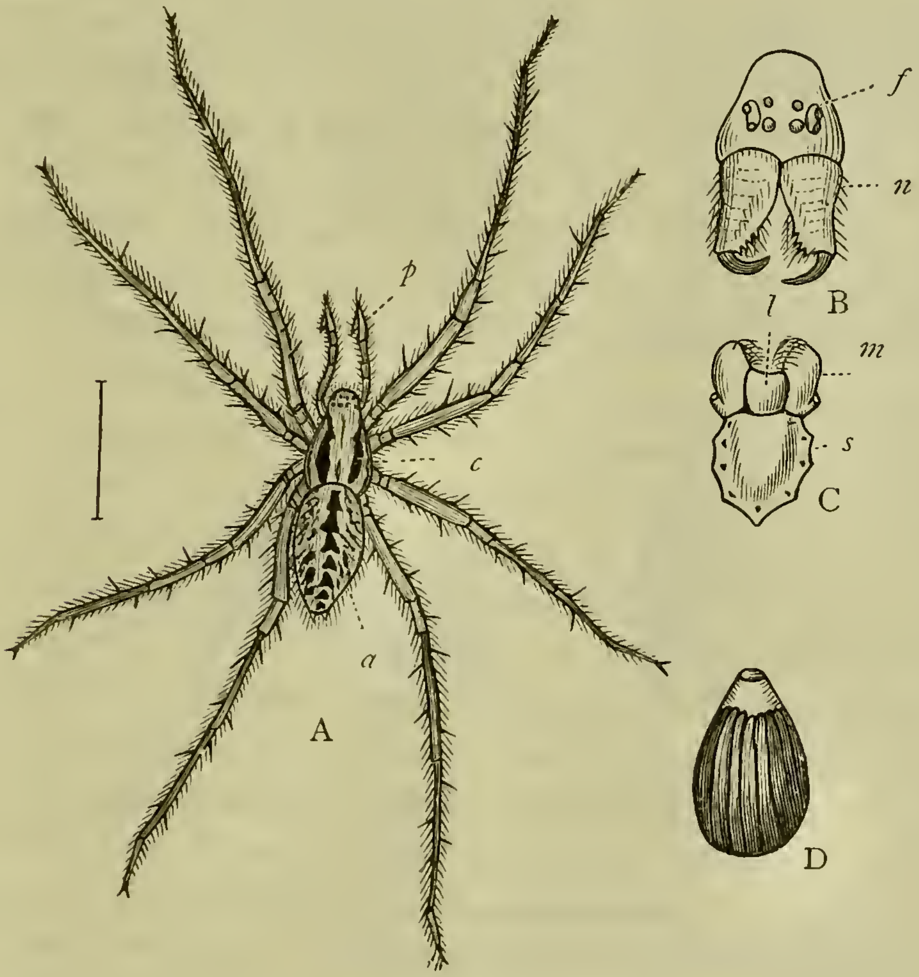


Fig. 47.—House Spider.

A, Male of House Spider (*Tegenaria civilis*) enlarged : *c*, cephalothorax ; *p* maxillary palpi ; *a*, abdomen. B, front of head : *f*, ocelli ; *n*, mandibles. C, under side of head : *m*, true jaws ; *l*, lower lip. D, diagram of one of the air chambers. (After Blackwall, from Nicholson.)

Araneida or Spiders.

The Spiders may be considered of economic importance, as they are all more or less of a beneficial nature. The food of spiders consists almost entirely of insects, and thus they do a considerable amount of good in keeping down an access of insect life which may be noxious to us. Some spiders hunt for their prey ; others, and those perhaps best known to us, have the habit of spinning webs, in which their prey is trapped. Spiders have either two, six, or eight eyes or ocelli (fig. 47, B, *f*), which vary in position and size, and which supply important characters of systematic value. The jaws with which the spider seizes its prey are inserted immediately under the anterior margin of the cephalothorax, and have, as a rule, on the extremity of their inner surface a groove, with sharp teeth at the sides, into which fits the fang when in a state of repose (B, *n*, and C, *m*). The fang or last joint of the so-called "falsis" is perforated by a minute hole at the tip, through which a colourless poisonous liquid exudes, secreted by the poison-glands within.

Perhaps the most important structural feature to notice in the spider is the presence of the so-called "spinnerets." These structures are placed at the end of the body, and consist of two, three, or four pairs of appendages. The spinnerets vary in form: some are cylindrical, others round, and some conical. The tip and under-side of these structures are perforated with minute holes. Through these minute apertures the liquid substance that will harden and form the silk of the web is passed. Thus it will be seen that numbers of minute threads of this glue-like liquid are passed out, and these unite into one firm yet elastic line of extreme fineness, but nevertheless of sufficient strength to bear a heavy-bodied spider. This line is also covered with little drops of a clear liquid (fig. 48, C), so that the spider's web consists of two substances—one forming the solid elastic thread, the other forming the little globules. There is a popular idea that the spider can withdraw its web into its body again: this is not correct. When once hardened, the web always remains so. In the spider's web, the viscid globular glue on the web is distributed only over certain areas: passages are left, so that the spider can walk along the web without coming in contact with the sticky substance. This substance is for catching and retaining the insects that fly into the web. In some spiders this webbing is formed for taking aërial flights. The so-called "gossamer" web is formed by strands of fine silk blowing about and adhering together, thus forming the white flaky masses. Some spiders may be found on these threads as they are being wafted about—the spider having, as it were, taken advantage of this mode of transit.

There are two chief divisions of spiders—the first having four spinnerets and four air-sacs, the second two air-sacs and six spinnerets. The former are known as *Mygalidæ*, or crab-spiders, such as the large Tarantula, or Bird-spiders, of the tropics. One large species is found in Britain—namely, *Atypus Sulzeri.* This carnivorous araneid excavates a subterranean gallery in damp places, in which the female, amongst the lining of white silk the tube is padded with, deposits her eggs, in a cocoon of pale silk attached to its end. A portion of this tube generally hangs outside the subterranean part, so as to protect it. Trap-door spiders belong here. The second division includes all the other spiders, those with which we are best acquainted, such as the *Epeiridæ*, or Orb-weavers, &c. (fig. 48, A). The *Drassidæ* (B) may often be noticed,—narrow-bodied spiders which live in tubular silken cells, open at each end. These cocoon-like masses we find under the bark of trees, and amongst moss and leaves: from these shelters the spider darts out to hunt its prey. For an account of these and other spiders the reader

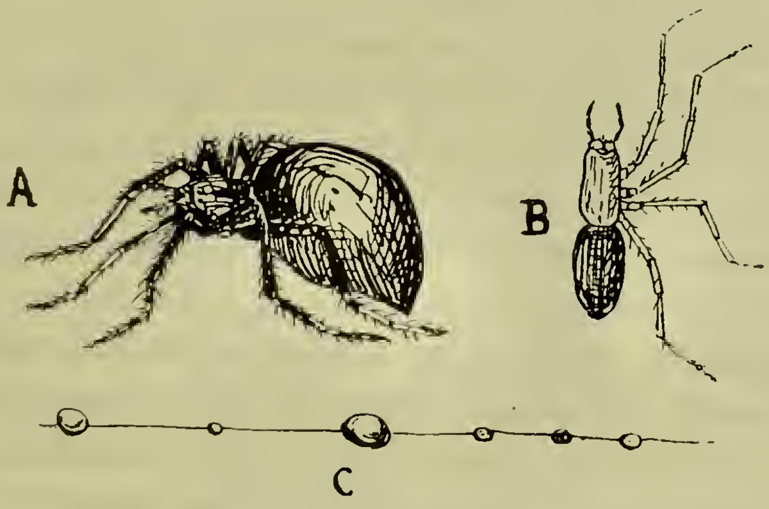


Fig. 48.—Orb-weaving Spider, Etc.
A, *Epeira diademata*; B, *Drassus Blackwallii*; C, thread of *Epeira* web.

is referred to Murray's excellent 'Economic Entomology,' which deals with spiders, mites, amd other Arachnoidea.

Acarina or Mites.

The mites are of great importance, as many of them are parasitic, not only upon animals and man, but upon plants. The Acarina are mainly very minute animals, many being no more than $\frac{1}{250}$th of an inch in length; and yet it is these minute forms that cause the most serious pathologic disturbances in animals (Scab, Mange, Itch, &c.) and the most serious plant diseases (Big Bud, Red Spider, &c.). In all mites, and the similarly grouped ticks, the head, thorax, and abdomen are united more or less into one solid body. The internal parasitic forms are generally white or pale-creamy colour. They are provided with a biting and piercing mouth. Amongst the more important diseases produced by them are sheep-scab, mange, and itch. They also affect poultry, causing feather-eating, scaly-leg, and in plants various "galled" appearances only too common on some of our fruit-trees. Some are predacious, and so beneficial. There are also species that live in the water. These latter we need not refer to again. Most mites, like spiders, have four pairs of legs when mature, the young having only three pairs. The more or less fused head, thorax, and abdomen soon separate them from the spiders. The so-called red-spider of the hop, *Tetranychus malvæ*, and the red-spiders of fruit, the *Bryobia ribis*, &c., can thus be readily seen to be acari and not araneida. Nearly all acari produce ova: some few are, however, parthenogenetic, and produce living young. The following are the groups of some importance to the farmer, fruit grower, and gardener:—

(i) *Trombidiidæ*, the so-called Spinning Mites or Red-spiders. These are found on the leaves of plants, and constitute the group *Tetranychi* (fig. 51), which can be told by their small size and usually semi-transparent bodies, sometimes however tinged with red. Closely related to these are the Harvest Bugs (fig. 49), which are generally of a brilliant colour, and may be found under stones, earth, &c., and sometimes, in some of their stages, as very noxious human and animal parasites.

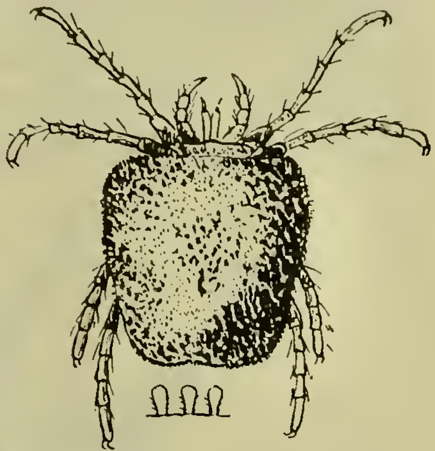


FIG. 49.—HARVEST BUG (*Trombidium holosericeum*).

Adult of the Harvest Bug. (× 10 times.)

(ii) The *Bdellidæ* or Snouted Mites can be told by the long snout and similar brilliant colouring of the body. Some are parasites on insects.

(iii) The *Gamasidæ* (fig. 52), some of which are also parasitic on animals and birds, have usually some modification of the second pair of legs to distinguish them.

(iv) The *Ixodidæ* (fig. 54) or Ticks can always be told by their leathery skin and by having a shield on the back behind the head.

(v) The *Oribatidæ* have a hard, chitinous, more or less shiny skin, and are known as Beetle Mites. These are often very beneficial (fig. 59).

(vi) The *Acaridæ*, colourless and nearly transparent.

(vii) The *Sarcoptidæ* (fig. 56) are the parasitic forms that produce scab, scaly leg, &c., and have a more or less transverse wrinkled skin and long suckers on some of the feet.

(viii) The *Phytoptidæ* (fig. 60) or Gall Mites, living in plants, are all minute and transversely wrinkled. They have only four legs, the two hind pairs being reduced to simple bristles. The mites live in the buds and leaves of plants, and produce galls and blisters.

Family **Trombididæ**.—The Red-spider of the hop, *Tetranychus malvæ*, may be taken to exemplify this family. They are extremely variable in colour, some being green, others rusty-red, others almost white and transparent; often dark specks are seen upon them, and in not a few instances brown individuals may be met with. This varied coloration is due to both age and food. These mites are so minute that they can scarcely be seen on the leaves without a lens. This and some others of the genus (*T. telarius*) spin webs of fine silk on the under-sides of the leaves. The legs, which are provided with bristles, take a prominent part in the weaving of this web, guiding the microscopic silken thread as it issues from the conical papilla near the anus of the mite. In and under this webbing the mites live and breed. The females lay their rather large globular eggs in this web. Sometimes the ova are colourless, at others they have a golden hue. Incubation takes place in from six to eight days, the young or larval mite being colourless, and has only six legs. After repeated ecdyses, the normal number of legs is attained. All these stages may be found in a single web at one time. The

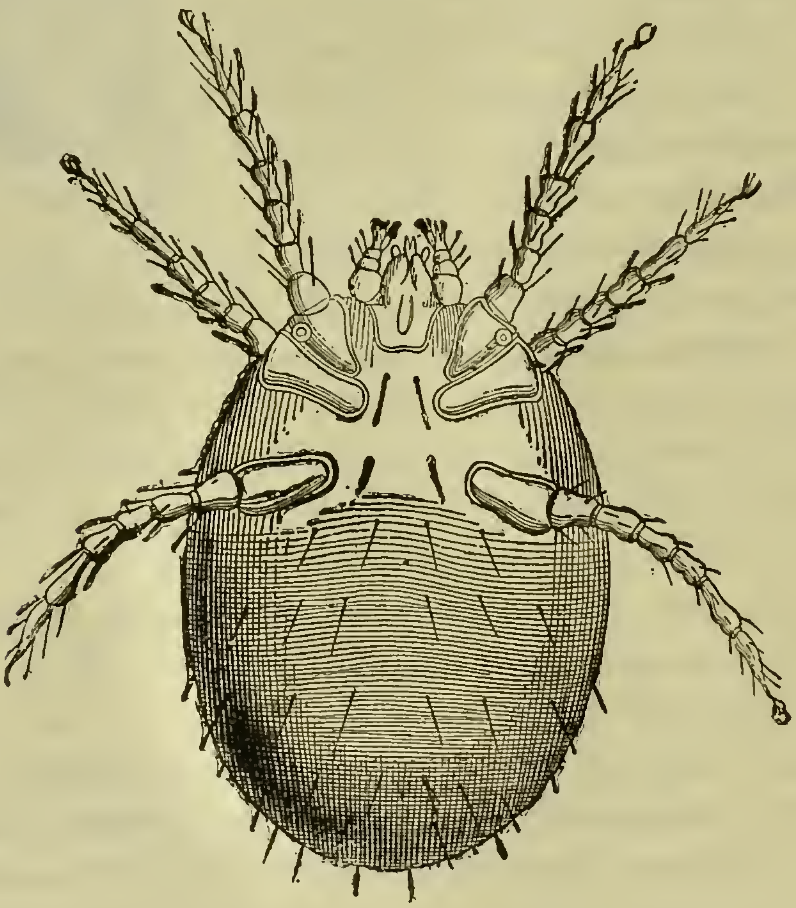


FIG. 50.—HARVEST BUG (*Leptus autumnalis*), the larva of *T. holosericeum* (magnified 100 diameters). Railliet. (From Neumann.)

females hibernate during the winter months, seeking shelter in such places as the cracks in hop-poles, under dead leaves, in soil, in all crevices and shelters where they are protected from frost and snow. These, and all mites, flourish best in hot and dry weather. They damage the plant in a twofold manner,—first by sucking out the sap, and secondly by blocking up the stomata of the plant by their webbing and excreta. The mouth consists of a pair of biting jaws and a sucking-tube between. The tissue is first bitten, and then the sucking-tube is thrust into the hole and the sap extracted. No mites, we must remember, have any external breathing-pores, but respire by the whole body-surface. All washes used for destroying them should contain sulphur or paraffin, as they are the most powerful acaricides. Liver of sulphur is found to be the best form of sulphur to use for these pests. The Red Spider of the vine (*T. telarius*) works in a similar way. It is best kept down by repeated sprayings of cold water.

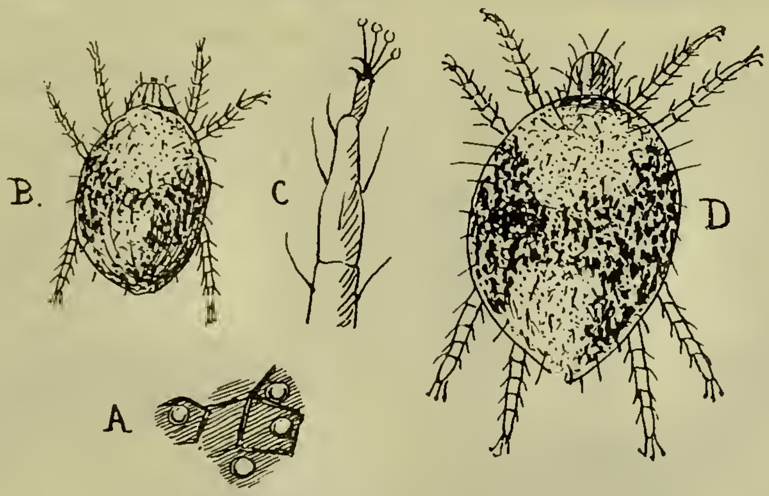


FIG. 51.—RED SPIDER (*Tetranychus malvæ*).
A, Eggs on leaf; B, larva; C, foot of mite; D, adult.

The genus *Bryobia*, which belongs to the Trombididæ, has several species destructive to fruit-trees. These fruit pests can be told from *Tetranychus* by having the first pair of legs long, whereas in *Tetranychus* they are all the same length. They spin no webbing. Mature Bryobia are about $\frac{1}{30}$ of an inch long. They hibernate as adults and eggs, but egg-laying usually takes place in March and April. They produce a marked, marbled, and rusty appearance on the foliage. They are best destroyed by winter spraying with caustic soda wash and spring spraying with paraffin jelly. Several others occur in a similar way attacking fruit and flowers. In this family is also placed the Harvest Bug (*Leptus autumnalis*), figs. 49 and 50. This larval mite is the young stage of *Trombidium holosericeum* (fig. 49). *T. holosericeum* is a scarlet mite with a squarish body covered with hairs and papillæ, about the twelfth of an inch in length. This mite, which is found crawling about upon the ground, deposits eggs in July. These ova hatch into minute, six-legged, orange-coloured larvæ, the so-called Harvest Bug, which lives as a parasite in the skin of man and many animals, and produces violent itching. When full grown the Harvest Bug is only ·4 mm. long. Many species occur in different parts of the world.

Family **Gamasidæ**.—In this family the mandibles are provided with very small nippers. They are found on the ground and as partial parasites. The legs are seven-jointed, the second pair being often larger than the rest. There are two claws to the tarsi. The colour is generally light brown, or white; some are reddish, owing to the blood drawn from their host. The most important form is the Red Hen Mite (*Dermanyssus avium*), which infests fowls and almost all birds (fig. 52). This mite, described by Redi, may be found in all unclean hen-roosts and pigeon-houses. It is provided with a sharp piercing mouth. It is a small mite, flattened, with bristly abdomen and stoutish hairy legs. In colour this gamasid varies from pale yellow to dark red. The larvæ, which hatch rapidly from the eggs, are white and six-legged. Like many partial

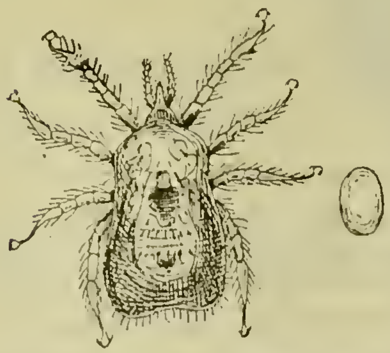


FIG. 52.—RED HEN MITE (*Dermanyssus avium*) and egg (greatly enlarged).

parasites, the hen mite is nocturnal, hiding away in crevices of the walls, &c., during the day-time. Sometimes they even attack the nasal cavities of the birds, and also other animals to which they may become transmitted.[1]

Family **Ixodidæ.**—The members of this family are popularly called Ticks. Ixodidæ are large Acari with a tough leathery skin, the front of the body covered with a hard protecting shield. All the ticks are blood-suckers, living some part of their life upon other animals, especially warm-blooded vertebrates and birds. At or near the front end is a very formidable beak or capitulum (fig. 53), composed of cheliceræ, and (B) a sharp piercing rostrum or hypostome with recurved barbs at the tip (A). When a tick is fixed on an animal it is impossible to pull it off: the body comes away from the head, which is held firmly fixed by the barbs in the host's skin. On the ventral surface are four pairs of legs in the adult, each leg consisting of six segments, the tarsus ending in a pair of claws, carried

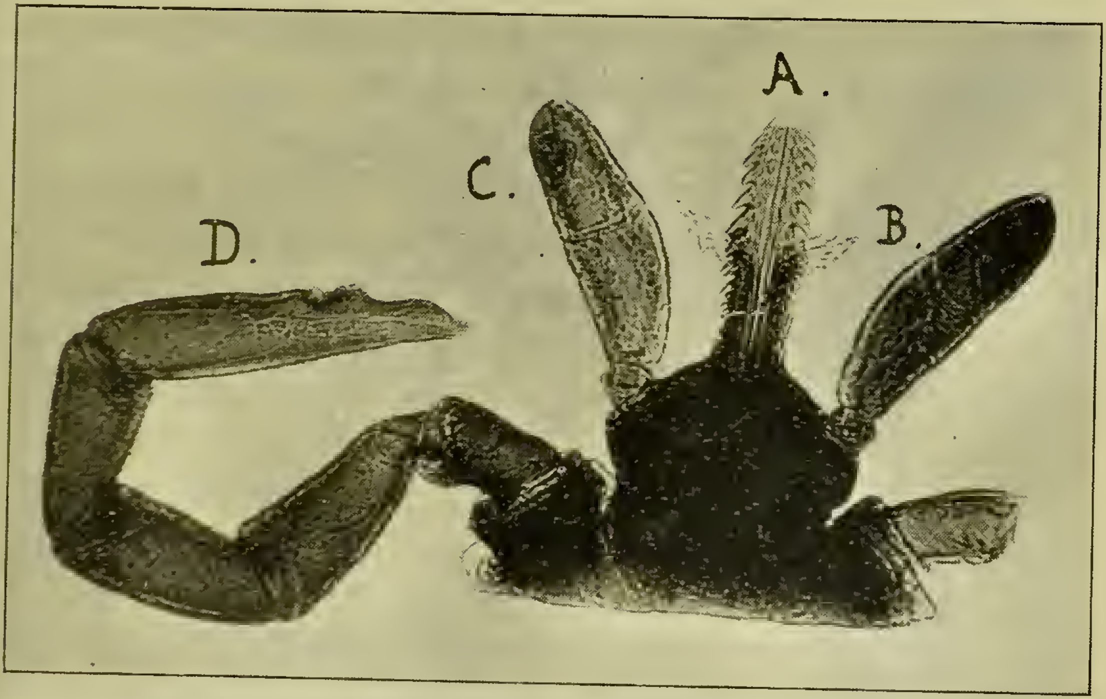


FIG. 53.—HEAD OF A TICK.
A, Hypostome; B, chelicerae; C, palpus; D, front leg showing Haller's organ.

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[1] The Parasitic Diseases of Poultry, p. 52. F. V. Theobald. 1897.

on a slender stalk, and in some with a membranous *pulvillus* between. On the anterior tarsi (fig, 54, *f*) is a narrow pit lined with sensory hairs (Haller's organ), probably olfactory (*f*). The sexual opening (*j*) in both sexes is on the ventral surface not far from the capitulum; the anus (*k*) is farther back. Ticks have spiracles (*h*), which lie behind and above the bases of the third or fourth pair of legs. The male tick is smaller than the female, and its body does not swell much. The hind part of the female's body is capable of very considerable distension, although tough. Ticks are found amongst grass, shrubs, and especially on sandy soil. When young they are quite small creatures, but very active. They are then six-legged, and are known as Seed or Grass Ticks. They crawl about over the grass and vegetation, and eventually get fixed on to some passing mammal or bird, from which they instantly commence to suck blood. During this temporary parasitism the body swells, owing to the quantity of blood taken in. When the larval tick has completed its

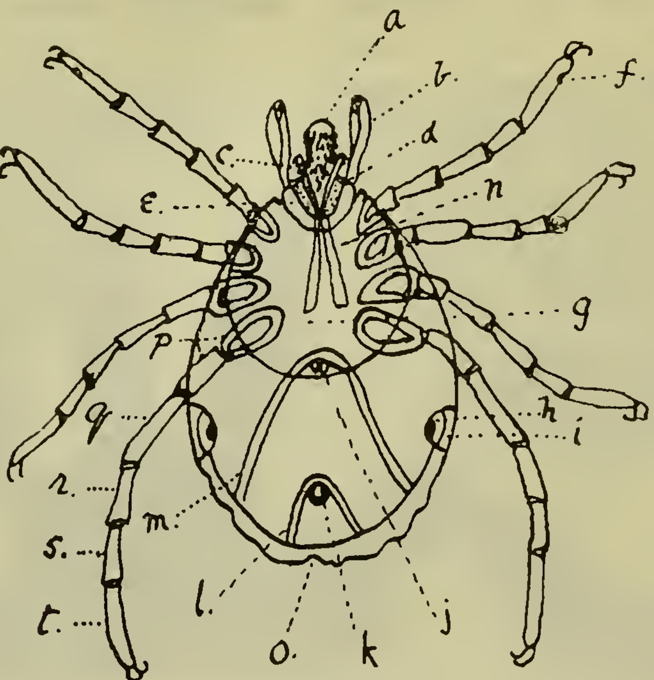

FIG. 54.—EXTERNAL PARTS OF A TICK. (After Wheeler.)

a, Hypostome; *b*, palpus; *c*, chelicerӕ; *d*, capitulum; *e*, rostrum; *f*, Haller's organ; *g*, scutellum; *h*, spiracle; *i*, peritreme; *j*, genital opening; *k*, anus; *l*, anal groove; *m*, genital groove; *n*, cephalothorax; *o*, fringe or marginal indentations; *p*, coxa; *q*, trochanter; *r*, femur; *s*, tibia; *t*, tarsus.

meal it falls from the host to the ground again, and may remain for some time without any food. It moults or casts its skin whilst on the ground, and becomes a nymph with eight legs, but is not sexually mature. This nymph then gets on to another host and feeds, then it falls to the ground again and moults for a second time. The adult stage is then reached, and the adult males and females wait until they can again crawl on to another host. The female then becomes much swollen out, being gorged with blood, so much so that the head and legs can scarcely be seen from above. The male only swells to a small extent. When the female is fully gorged and fertilised she falls to the ground and lays her eggs in long masses (fig. 55). The act of copulation is peculiar, the male inserting the proboscis into the vulva of the female and so injects the spermatophores.

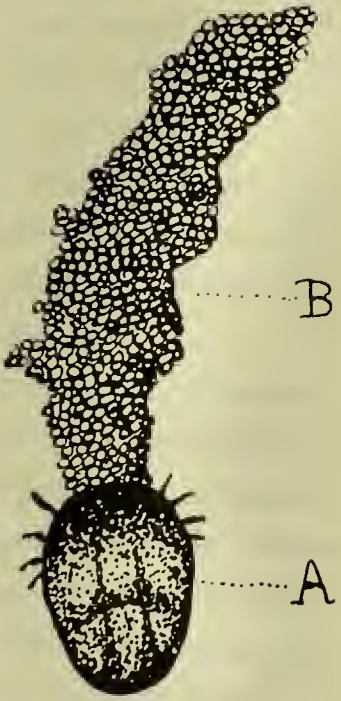

Fig. 55.—Female Tick (a), laying Eggs (b).

Thus some Ticks require three hosts to complete their development (*Rhipicephalus appendiculatus*); others, however, only require one host (*R. decoloratus*), the larva and nymph not falling to the ground but moulting on the host.

Others require two hosts (*R. evertsi*), which remains on the host for the first two stages.

Some Ticks may live a long time even without food. The writer has kept one, *Ornithodorus moubata*, for over a year. Normally the true Ixodidæ are not long-lived, but under abnormal conditions they may be. Wheeler kept *Ixodis ricinus* alive for two years, and a female which had no head and could not have taken any food. The importance of Ixodidæ is not only on account of their blood-sucking habits, which cause severe irritation to animals and birds and man, but especially because of the part they play in the spread of such diseases as redwater or Texas fever and East Coast fever in cattle, of malignant jaundice in dogs, of heartwater in sheep, and human tick fever, &c.

The Ixodidæ are divided into two sub-families :—

(i) *Ixodinæ*, which have the rostrum terminal in all stages.

(ii) *Argantinæ*, in which it is inferior in the adult and sub-terminal in the larva and nymph.

The *Ixodinæ* are the so-called Hard Ticks, the dorsum of the body being protected by a shield or scutum, and the posterior part of the body may be cut into festoons, especially in the males. The scutum is small in the females, large in the males. They are all fixed parasites, and when the female has laid her one batch of eggs she dies. It is these *Ixodinæ* which carry the animal diseases such as redwater, carried by *Rhipocephalus* (*Boophilus*) *annulatus*, and which attacks only one host. In this case the larvæ, coming from ova laid by the tick that has fed on a beast with redwater, is pathogenic, and so gives the disease to its host carried on from the parent. But in the case of the carrier of the piroplasmæ of malignant jaundice—a tick called *Hæmaphysallis*—the parasites are not ready for the dog until the ticks have become mature—that is, larvæ and nymphæ coming from the ova of a female that has fed on a jaundiced dog cannot give the disease, but the adult can.

The *Argantinæ* are the Soft Ticks, and these have no dorsal shield, and the head is not visible from above, but lies in a shallow groove (*camerostone*). The adults do not attach themselves permanently to their host, but only go to feed, and then crawl away. They attack birds and mammals and man. Instead of dying when eggs are laid as the female Ixodine does, they live and grow for years, and the female produces many batches of eggs.

One well-known species is the Fowl Tick (*Argas persicus*), which spreads the fatal disease "spirillosis." Another, once found in Canterbury Cathedral, *A. reflexus*, especially attacks pigeons, its bite often proving fatal. Here also comes *Ornithodorus moubata*, the carrier of African tick or relapsing fever.

These ticks hide away in crevices, in buildings, in sand, &c., and come out to feed when necessary.

Ticks may be destroyed on sheep by dipping, and also, as is now done in Africa, by spraying the cattle driven through narrow runs. Burning of the grass on tick-infested land also does some good.

The following are pathogenic species :—

Ornithodorus moubata—On man, birds, &c. (human tick fever, &c.).

Amblyomma hebrœum—On sheep and goats (heartwater).

Hæmaphsyllis leachii—On dogs (malignant jaundice).

Rhipocephalus decoloratus—Cattle, &c. (redwater in Africa).

Rhipocephalus australis—Cattle (redwater in Australia).

Rhipocephalus annulatus—Cattle (redwater in America).

Rhipocephalus simus and *Rhipocephalus appendiculatus*—On cattle, &c. (East Coast fever in Africa).

Ixodes ricinus—On cattle, &c. (redwater in Europe).

Family **Sarcoptidæ.**—These minute mites live as parasites in and upon animals and man. The body is round or oval; in front is a conical rostrum. The sexes are told by the differences in the legs and general shape of the body and by the size, the male being always much smaller than the female. They occasion diseases that are spoken of as Scabies or Psoric diseases. The Sarcoptidæ are the smallest of all mites, varying from ·1 mm. to 1 mm. ($\frac{1}{25}$ inch) in length. No eyes are present, and respiration is cutaneous. The Psoric Sarcoptidæ attack the epidermis of animals, and the punctures they produce, with the addition of a poisonous saliva, give rise to thick crusts over their point of attack. The Sarcoptidæ are oviparous and ovoviviparous. The eggs are slightly ovoid, and the contained embryo is easily seen in an ovum in an advanced stage. The eggs incubate in a few days. In some cases the author has observed the ova to hatch in two days in the species producing Sheep Scab; more usually seven to ten days is the period.

The metamorphosis is as follows :—

The *Larval* or first stage is a small acarus with only three pairs of legs and no genital organs, and with two long anal bristles. The larva moults two or three times. Then follows the second or *Nymph* stage. The *Nymph* has a fourth pair of legs, which are, however, small. As yet no sexual organs are to be found. We observe two sizes of nymphs ; the small ones will be males, the large females. Casting their skin, both males and females are produced, and then copulation takes place. They are then known as *pubescent males and females.* The male soon dies ; but the female undergoes another moult, and becomes the *ovigerous female,* with a sub-thoracic vulva, and then deposits about fifteen large ova. Gerlach states that one female, having given rise to six generations, is accountable for 1,500,000 individuals in about ninety days.

The *Sarcoptes* have a rounded body. The posterior legs are very small, and nearly or quite concealed beneath the body. The ambulacral sucker is in the form of a simple long pedicle. The females deposit their eggs at the bottom of the furrows they excavate in the sub-epidermic tunnels. *Psoroptes* have a more oval body, all the legs are visible, and the ambulatory suckers are borne on large three-jointed pedicles. The psoroptes do not make sub-epidermic galleries, but live in societies amongst the crusts they cause on the skin. *Symbiotes* are oval, and have all the legs visible outside the body margin, with the claws borne on a broad, short, and simple pedicle. These live like psoroptes in colonies under the scabs, and cause more localised patches than the others.

Each domestic animal has a variety common to it ; but it is said that the itch of man can be taken by the dog and other animals, a point which cannot be accepted as proven. The sarcoptic mange of the horse, however, can be easily transmitted to the ox. Regarding the transmission from one animal to another and man, there is much diversity of opinion.

Sheep-scab.

The Scab or Soab of sheep is of three types, produced by the three genera of *Sarcoptidæ*. The commonest form of scab is that produced by *Psoroptes communis* v. *ovis*. It is sometimes called Demodectic Scabies. The acarus (fig. 56) can just be seen with the naked eye, and may readily be found under one of the scabs in all stages. The female Psoropt of the sheep has a large round body with four pairs of short legs, the third and fourth pairs being of nearly equal size; but the third is devoid of the curious sucker on the feet. The male has the fourth pair of legs very short, the third pair being long, and armed with the sucker. The ova laid by the female are comparatively large ovoid bodies, which are deposited at the edges of the scab. I have kept the ova for two months, at a temperature of 30° Fahr., without their incubating; but when the temperature was raised to 67° Fahr. they soon hatched out. In the summer five to eight days is, however, the period of the egg-stage. The larva is much narrower than the adult, and has only six legs, the fourth pair not being developed until later in life. In fourteen days the larva casts its skin for the first time, and then ten days later another moult takes place. By the thirty-eighth to the fortieth day of its existence a third moult brings it

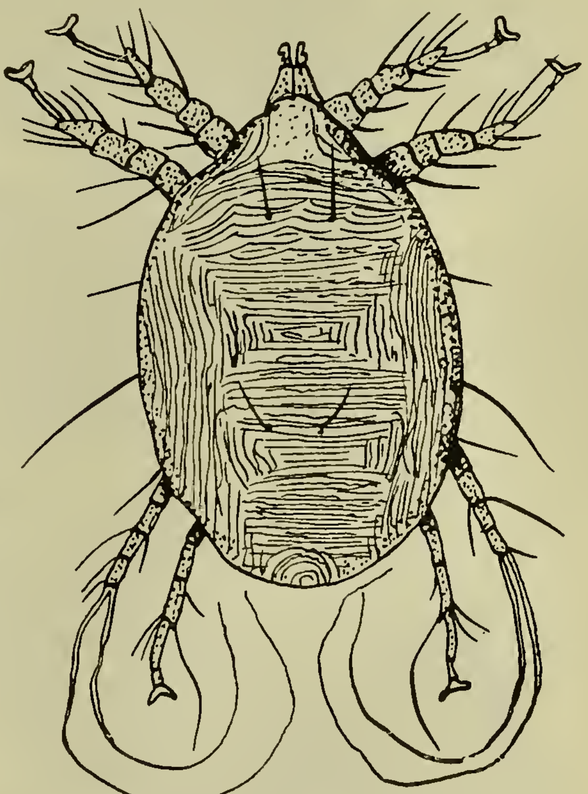

FIG. 56.—FEMALE SHEEP-SCAB MITE.
(Greatly enlarged.)

nearly to maturity. When about two months old the acarus commences to lay. Some authorities say they mature much sooner. The larvæ become eight-legged when the *nymph* stage is assumed. They remain attached to the leg-bristles of the ovigerous female for some little time after birth. The adult mites live for three or four weeks. Psoroptes may be found amongst the wool and under the scabs, but never tunnel in the *true skin.* One can watch a young mite burrow into the outer skin or cutis: in about ten days a small nodule will arise over the point of entry; from this vesicle a yellowish exudate appears, which hardens over the skin, forms a scab, beneath which the mites breed, being especially prevalent at the edges of the psora. The scabs usually commence to be noticeable about the sixteenth day after entry. This psoroptic mite, the true scab acarus, is found chiefly affecting the woolly regions of the sheep; it is seldom found on the head or legs, or on the abdomen beneath or breast region. The disease seems to die out spontaneously, especially after dipping and shearing. The acari often become detached on the wool the sheep rub off, when trying to relieve the pruritus set up by them. Other sheep rubbing against the wattles, pens, hedges, &c., where this diseased wool is, will soon contract the malady, and so the disease is spread from one flock to another.

The *Sarcopt* known as *S. scabiei* v. *ovis* produces the head-scab. This mite attacks those regions devoid of wool, or at least where it is scanty. It is particularly plentiful around the eyes, ears, nostrils, and lips. Youatt speaks of it as "black muzzle." It may spread to the belly and legs, especially the hocks and pasterns. The mite is round and white, with numerous spines of two sizes on the dorsal surface, and with two pairs of anal bristles. Legs short; the two first pairs have the curious suckers before referred to in the male, the fourth pair also having them; the third pair in the male, and third and fourth in the female, are armed with a long spine. This head-scab is very like the itch-mite in man — in fact

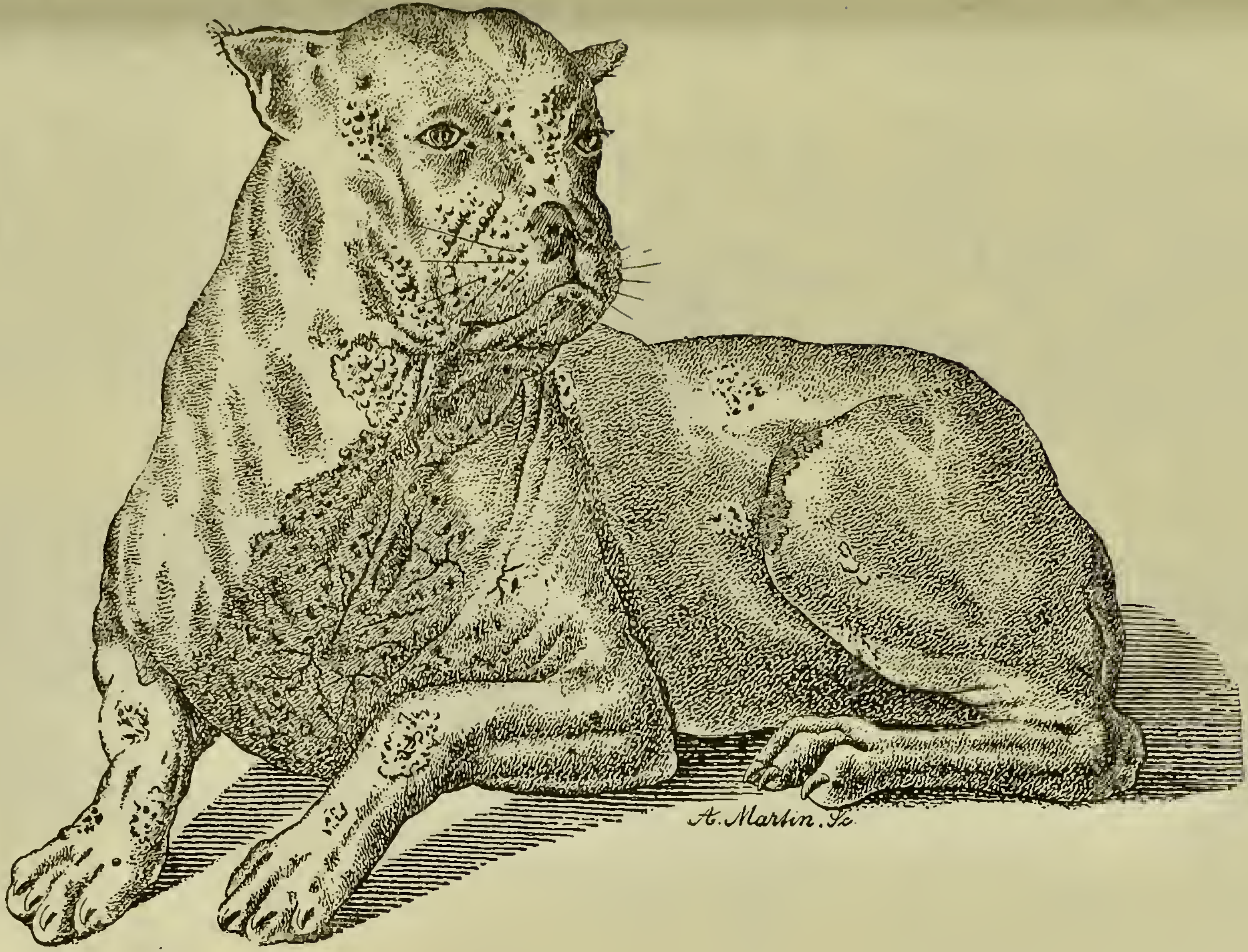

Fig. 57.—Red Mange.

A dog with advanced demodectic scabies. (From Neumann.)

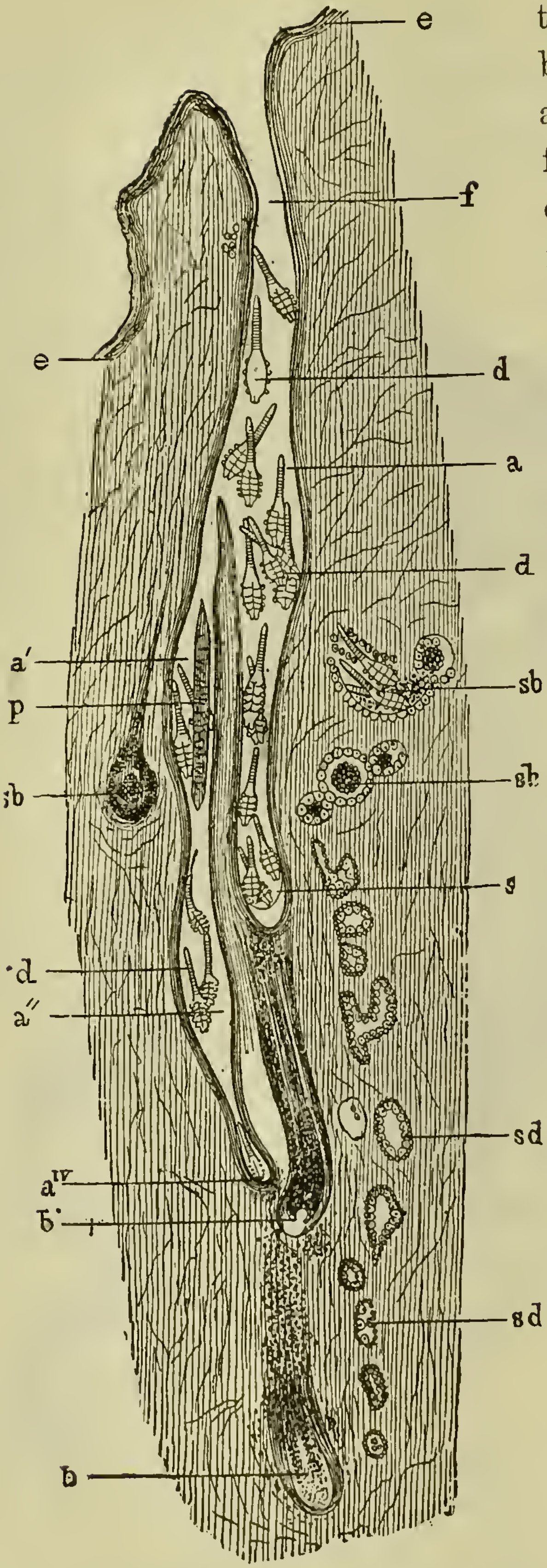

Fig. 58.—Demodectic Scabies. Section of skin, magnified forty diameters. (Laulanié.)

e, Epidermis; *f*, hair follicle; *P*, hairs; *b b′*, bulbs of hairs; *a* to *a*^{iv}, dilations due to Demodex accumulations, *d*; *sb*, sebacious glands; *sb′*, gland with Demodex; *sd*, sudoriparous glands. (From Neumann.)

this form may possibly be transmitted to man and other animals. The female Sarcopt lays her eggs in tunnels *in* the skin, not under the scab as in Psoroptes. Then small papules appear on the skin, which on being rubbed pass out a clear exudate, hardening and forming a crust or scab of a dirty-grey colour. The skin becomes hard and deeply folded, and blood may be seen oozing out in the cracks.

The third form, *Symbiotes communis* v. *ovis*, is not of common occurrence. The Symbiotes live in colonies, but do not excavate any sub-epidermic galleries. They are oval, not rounded, and the legs are longer and more easily seen. The legs are chiefly attacked by this form of mite, similar to the attack in the horse, producing red patches on the skin and very thin scabs. It is of little importance in Britain.

Varieties of Sarcoptes, Psoroptes, and Symbiotes are also found on the horse, pig, ox, goat, dog, and cat, producing various forms of "mange." Sarcoptes (*S. mutans*) also produce the "scaly leg" of fowls.

Another form of Scabies is produced by some mites known as *Demodicidæ.* These acari live in the hair follicles and sebaceous glands, and produce the so-called red mange in dogs (fig. 57). The same species, *Demodex folliculorum*, is found on man and varieties on other animals. In dogs (v. *canis*) this follicular mange appears as red patches around the eyes, and spreads over the body. It commences as red spots, which gradually become purulent. In the matter from these pustules will be found the mites (fig. 58), and also in the hair follicles.

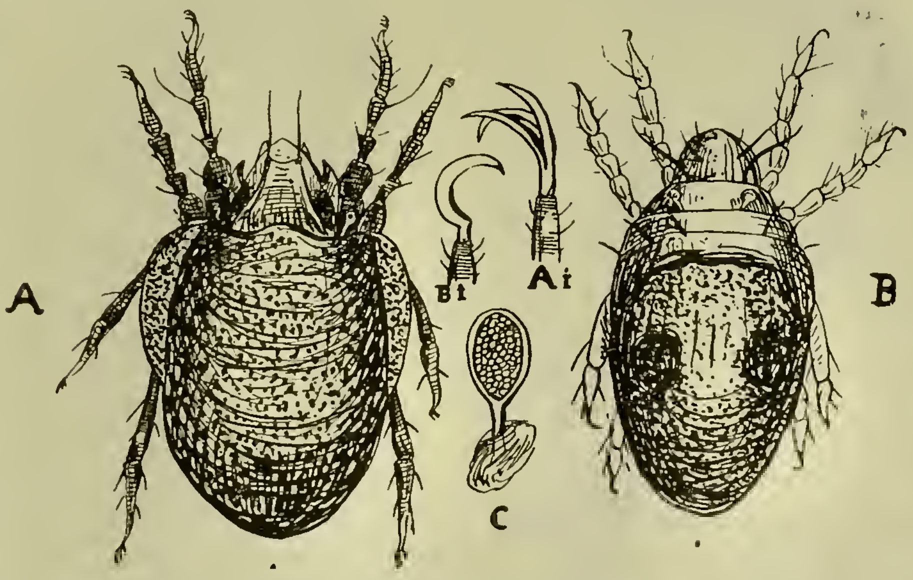

FIG. 59.—BEETLE MITE (*Oribata orbicularis*).

A, Adult; B, immature form following the six-legged larval stage; C, pseudo-stigmatic organ; Ai, ungues (claws) of adult; Bi, ungues of B.

Family **Oribatidæ** or Beetle Mites are so called on account of their hard covering of integument. Many of them are shiny objects which cluster together upon the trunks of trees, especially fruit-trees. They have a pair of very curious processes situated on the progaster; these two bodies are called pseudo-stigmata (C, fig. 59). One of the most abundant forms is *Oribata orbicularis* (fig. 59), which varies in colour from deep shiny black to brickdust-red. This mite may be found in large clusters on the bark of plum, damson, and other trees, where it feeds off the spores of lichens, fungi, and the ova of other mites. The adult has tridactyle (A i) claws; the larva and nymph unidactyle claws (B i). The larva, like most mites, is at first six-legged, but assumes four pairs before the sexual adult stage. Miss Ormerod mentions another very abundant species in her Report for 1897—namely, *Oribata lapidaria*, which has a similar life-history. These mites must not be confused with the mites that are parasitic upon beetles and the *Bdellidæ* or Snout Mites that we find on other insects.

Family **Eriophyidæ**[1] or Gall Mites are minute mites which live in the buds (*Eriophyes ribis*, *avellanæ*, and *taxi*) and in the leaves of plants (*E. pyri*). The former produce large swollen buds which never produce fruit; the latter gall-like patches on the leaves. Only two pairs of legs are noticeable in these minute acari, but the two posterior pairs may possibly be represented by four bristles. The skin of the Eriophyidæ is always more or less wrinkled or striated, and may or may not have a few scattered hairs. These acari stop the growth of the plant by destroying the buds, sometimes, as in the Currant Gall Mite (*E. ribis*), eventually killing the bush; at others, as seen in the Yew Mite (*E. taxi*), they produce stunted and deformed trees.

The **Currant Gall Mite** (*E. ribis*) (fig. 60) is especially prevalent on the Black Currant, where its presence may be detected in spring by the large swollen green buds which do not generally burst into leaf or blossom: in winter these large buds may still be seen, and many are brown in colour and dead. On examining the live buds in the winter we find all the acari safely housed: here they live and breed. In the spring and summer they come out and move over the bushes, taking up their position in new buds, which they speedily deform. The ova are laid in the buds, and soon hatch into mites very similar to the adults. In form the Currant Gall Mite is elongated and dirty-white in colour. This serious pest, which has spread at a tremendous rate over Britain, has now appreciably been checked.

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[1] Formerly called *Phytoptidæ*.

Some varieties, such as Balwins and Black Naples, are especially prone to it; others, as Boskoop Giant, seem to resist it. Hand-picking will keep the disease in check. It also attacks red and white currants.

The **Pear Leaf Blister Mite** (*E. pyri*) is found in winter sheltering under the bud scales. As the buds open the mites crawl out and enter the leaves through the stomata on the under sides. They then live and breed in the leaves, and produce pale or sometimes red (on young leaves) areas or galls, which later turn black. They even attack the young fruitlets and ruin them. As the leaves harden off they crawl back to the buds. This Leaf Gall Mite is also found in America and South Africa and Australia. It may be kept in check by winter spraying with lime and sulphur, and spring spraying with paraffin jelly.

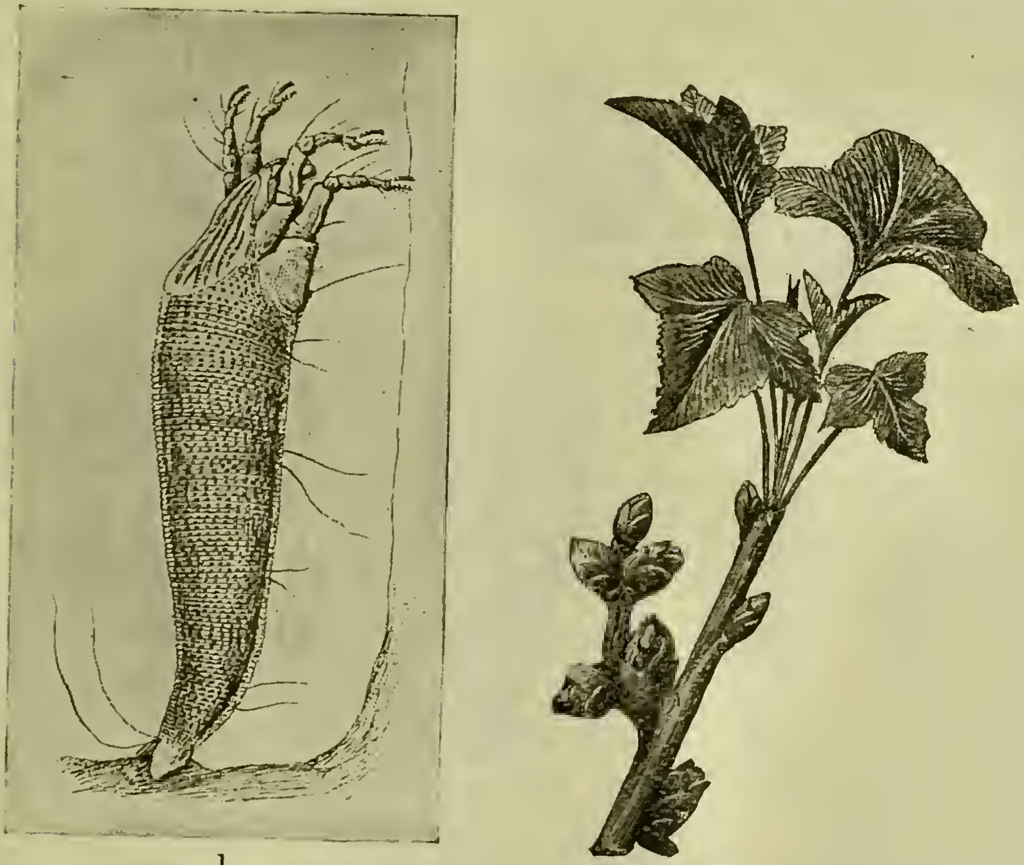

Fig. 60.—1, Black Currant Mite (much magnified) erecting itself upon its terminal suckers (after E. J. Lewis). 2, Twig of Black Currant in which an uninjured bud has opened. Two lower buds are hindered by presence of mites, while the lowest buds are swollen by them.

Linguatulidæ.—There are two quaint genera of Arachnida classed in the above family—namely, *Pentastoma* and *Linguatula*. These curious worm-like Arthropods are parasitic, living in the head and air-spaces of animals: they are more or less elongated and vermiform in shape when adult, and have a distinct annulated body. The mouth in the imago has no jaws, but is surrounded by two pairs of hook-like legs. Like Acarina they respire cutaneously. The one figured (fig. 61, E), *Linguatula tæniodes*, is the commonest form, and may often be found in domestic animals. At one time it was considered a tapeworm, and unless carefully examined it certainly resembles some of those worms. This acarus is dirty-white in colour, about three-fourths to one inch in length in the male, somewhat larger in the female. The female is often brown when full of ova. These arachnida live in the nasal cavities, especially in the dog, and there the female lays her eggs, which are sneezed out by

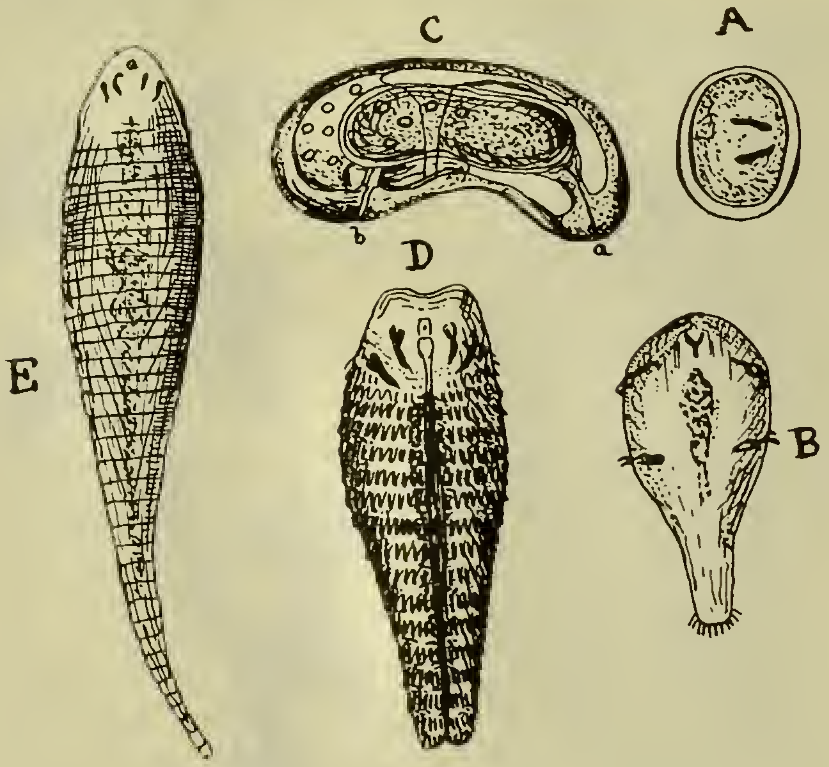

Fig. 61.—Linguatulidæ.

A, Ovum. B, Larva. C, Pupal stage: *a*, anus; *b*, mouth. D, *Linguatula denticulatum*. E, *L. tæniodes*. (After Railliet and Leuckart.)

the dog along with mucus. The ova are eaten by sheep, oxen, rabbits, and other herbivora, when the embryos (B) are released in the intestines. By means of the median rod and curved hooks this minute embryo bores through the intestines and gets to the liver, lungs, and mesenteric glands, where encystment takes place. It here soon becomes converted into a simple rolled up pupa (C), with no legs, hooks, or bristles. By a repeated series of moults a second larval form is reached (D), and which is said to last for seven months, by which time it has grown to the length of one-third of an inch. In this stage it was taken to be a distinct species called *L. denticulatum.* Numerous spiny rows are present on the skin. They fall from the organs they are in, to the body cavity and pleural spaces, and the majority die. Some, however, encyst themselves in fresh parts of their host, and even enter the air-tubes, and are so passed out of the host; or they may possibly enter the nasal cavities of the herbivora they live in, during their early life. More generally they reach maturity in the nasal cavities of the carnivora which happen to eat the flesh of infected herbivorous animals. In this last host they become sexual adults (E), with a smooth ringed skin, and are vermiform in shape. The males wander about the pharynx, larynx, and nasal cavities, and fertilise the stagnant females, which take up their abode between the turbinated bones and other nasal spaces. One female, according to Leuckart, may produce 500,000 eggs. They sometimes occasion loss, but are not very prevalent in Britain. Dogs should not be given the fresh viscera of sheep, oxen, &c., and then there would be no chance of any such disease appearing in a serious form.

CHAPTER VIII.

HEXAPODA (INSECTS).

The Insects proper, more correctly termed Hexapoda on account of the number of their legs, have received a large share of attention economically. Certainly this is justifiable, for the damage they often occasion is very severe, not only to crops, but also to stock and man.

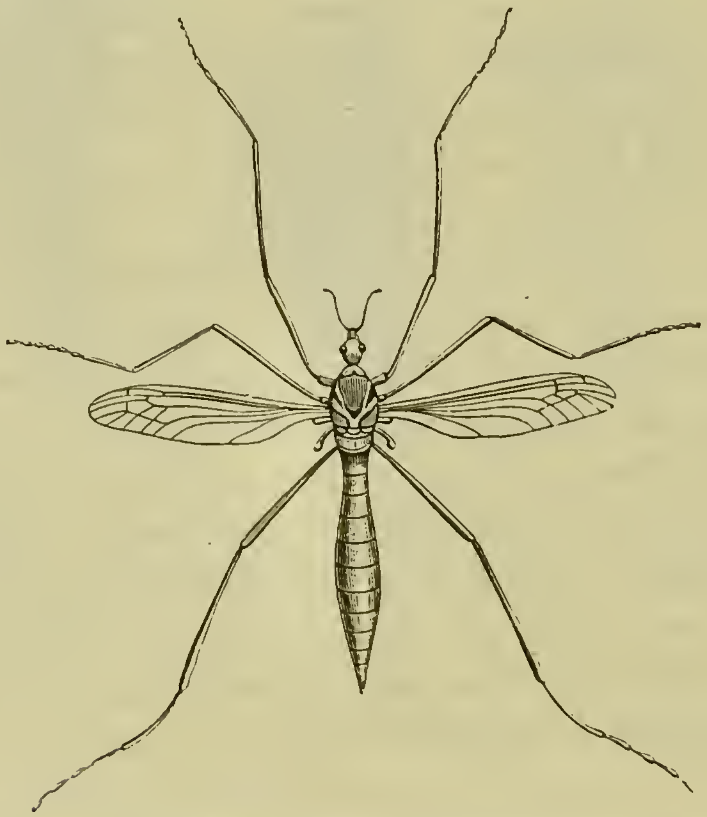

Fig. 62.—A Hexapod (*Tipula oleracea*). Note the six legs on ventral part of thorax. (Nicholson.)

Insects are characterised by possessing three pairs of jointed legs, attached to the thoracic region on its ventral surface. This feature will at once separate them from all other Arthropods. Respiration is tracheal, the openings or spiracles being slit-like apertures along the sides of the abdomen, in addition to two pairs on the thorax. The typical mouth of an insect is described in chapter vii. This is a biting mouth, a type of oral structure we find in many injurious insects. Others are provided with a piercing mouth, and live upon plant sap and animal blood, often causing serious loss to the farmer and stock-breeder, as well as spreading such human diseases as malaria, yellow fever, filariasis, and basilero. The third form of mouth, the sucking mouth, usually prevents those insects possessing it from doing any damage; but there are some moths whose proboscis is so hardened that they damage fruit in South Africa. Those groups with this latter type of oral structure aid more or less in the fertilisation of plants. It will be chiefly, then, amongst the biting and piercing mouthed insects that the injurious species will be found. But we must bear in mind that many suctorial mouthed insects have mandibulate larvæ, which can do as much damage as the true mandibulate groups. Many

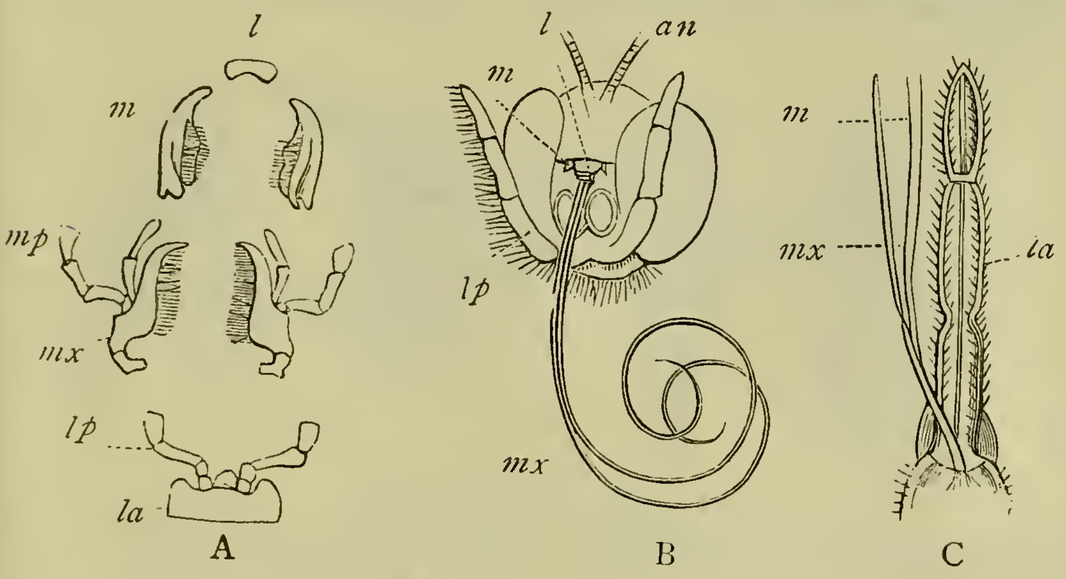

Fig. 63.—Mouth Parts of Insects.

A, Biting mouth parts; B, sucking, and C, piercing mouths: *l*, upper lip; *m*, mandibles; *mx*, maxillæ; *mp*, maxillary palpi; *la*, lower lip; *lp*, labial palpi; *an*, antennæ. (Nicholson.)

insects are distinctly beneficial by destroying other noxious insects (Chalcididæ, Coccinellidæ), and a few are of no inconsiderable commercial value (silkworms, cochineal, honey-bee, lac insects).

Insects commence their life in most cases as eggs or ova produced by a female. Some have the power of bringing forth living young (viviparous), as we shall see takes place in the Plant Lice (Aphididæ, &c.) In insects the ovum gives rise to a larva: this state is the period during which the insect grows. Larvæ of insects are known also as maggots, grubs, caterpillars, and false-caterpillars. *Caterpillar* is a term applied to coloured, often hairy larvæ, provided with six true legs and generally with four pairs of prolegs or sucker feet, in addition to the anal proleg (fig. 64, C). The number of these mid prolegs is sometimes reduced to two or four (Geometridæ and Plusiadæ), (A and D). These fleshy prolegs enable the caterpillars to hold on to the vegetation they are feeding upon. *False-caterpillars* are the larvæ of the Sawflies (*Tenthredinidæ*); they have more than four pairs of central sucker feet—usually the legs number twenty-two in all (B). *Maggots* are legless, fleshy larvæ of the Diptera or Two-winged Flies; often dirty-white in colour, and tapering to a point in front, blunt at the tail end. Some have a distinct head (Tipulid larvæ), others

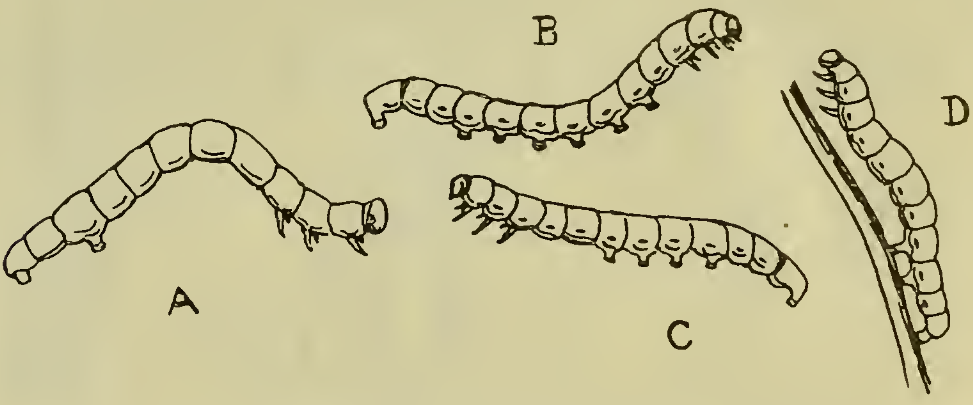

FIG. 64.—LARVÆ OF INSECTS.

A, Geometer larva; B, Sawfly larva; C, typical Lepidopterous larva; D, larva of *Plusia*.

are headless (Onion Fly maggot). *Grub* is the term generally given to the larvæ of some beetles (Weevils) and Hymenoptera (such as Wasp grubs). In the larval stage the insect often feeds with great voracity. Several ecdyses take place, the skin splitting after stretching to a certain limit; the larva ceases to feed during this period of moulting. Frequently after each moult, of which there are four or more, the larva presents a different coloration. The internal anatomy of the larva of insects that undergo a complete metamorphosis is different to that of the adult. Fig. 67 shows the digestive tract of the larva of one of the Daddy Long-legs (*Tipula*), which will be seen to be of quite a different type to that given in fig. 41. There are considerable differences in the digestive tract of insects. We shall observe much variation in the length of larval life when studying this group: some larvæ live only a few days; others, as the Wireworm, as much as three or four years. Eventually the "full-feed" state is reached, and the larva ceases to feed; it is then ready to assume the next stage—namely, the pupa, chrysalis, or nymph. Prior to entering this condition the larva either enters the ground and forms a cell in the earth, or spins a silken cocoon, or attaches itself by silk to some object (fig. 65, c), or finds some shelter in which to pupate. Typically the pupal stage is a period of rest, no

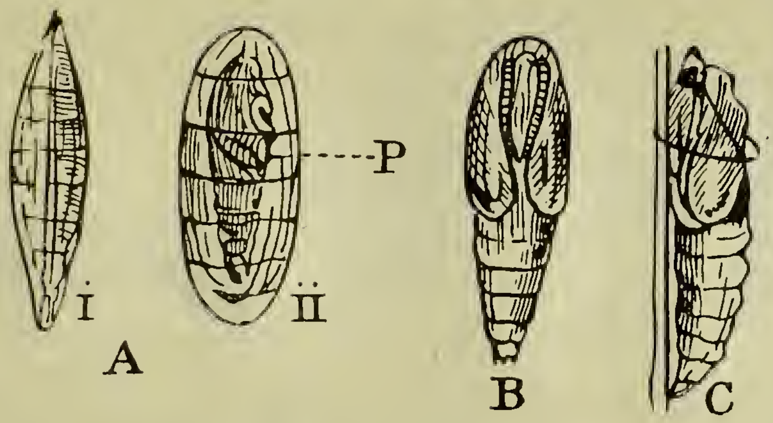

Fig. 65.—Pupæ of Insects.

A, Puparia of Dipteron; B, pupa of moth; C, chrysalis of butterfly.

food being taken. The pupal skin shows the general outline of the insect—legs, antennæ, wings, &c., being clearly defined (fig. 65, B). Chrysalis is the term generally used in Butterflies, which are pale-coloured and more or less angular (C). In Flies, and some Hymenoptera, the pupa is found in the old larval skin, which hardens and forms a brown case, called the *puparium* —the "flax-seed" stage of the Hessian Fly (A, i). In *some* diptera the pupæ are spiny (fig. 66). During this pupal period the majority of the larval organs are broken down into a soft granular mass, which becomes remodelled into the adult. This process is called *histolysis.* The pupal stage, again, is very variable in length, but not to such an extent as in the larva. There are often two or more broods, or generations, of insects during the year; in some the summer pupal state only lasts a week or so, whilst the winter pupal state lasts some months. Insects pass the winter in all four stages, many as ova (Vapourer Moth), others as pupæ (Hawk Moths), whilst some hibernate in the larval (Currant Moth) and adult (Tortoise-shell Butterfly and Queen Wasps) conditions.

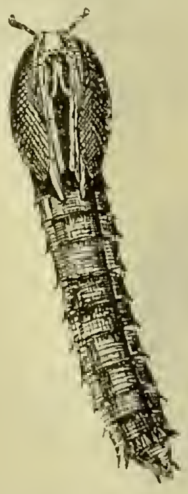

FIG. 66. — PUPA OF TIPULA OLERACEA. (Slightly enlarged.)

Injuries are caused by insects both to plants and animals. The damage is done in a variety of ways, such as by eating the leafage, by tunnelling into the stems and leafage, boring into fruit and seeds, and boring into the stems, even into the hardest wood. Both growing and stored grain and seed are attacked, also provisions, household goods, and furniture. Animals are attacked by insects sucking their blood, and others have parasitic habits, as exemplified by the Gad-flies and Warble-flies respectively.

The senses of insects are of much interest to us, and well worthy of our study. Sir John Lubbock's work on the 'Senses of Insects,' which treats this subject most fully, shows that it is one of some importance economically, as well as of deep interest. That insects have the sense of smell well developed we know for certain. Whether the palpi or the antennæ, or both, are connected with this sense is not quite clear; most probably the antennæ are chiefly functional in this respect. The sense of vision is acute, as any one knows who has tried to catch an insect settled on some flower; whilst we cannot doubt that taste is as surely present, when we consider the partiality certain insects have for certain foods.

To return once more to the changes through which an insect goes—the so-called *metamorphosis*. Insects which pass through the stages enumerated on p. 141, in which the larva is quite unlike the adult, and where there is a distinct quiescent pupa, in which the larva is transformed into the imago, are said to undergo a *complete metamorphosis*. There are many insects which have no quiescent pupal state, and where the larva is very similar to the adult. The whole life-cycle from the egg onwards is one of activity except when the insect is moulting. The pupal stage is simply distinguished by the small swollen wing-buds seen at the sides of the thorax. These insects are said to have an *incomplete or gradual metamorphosis*.

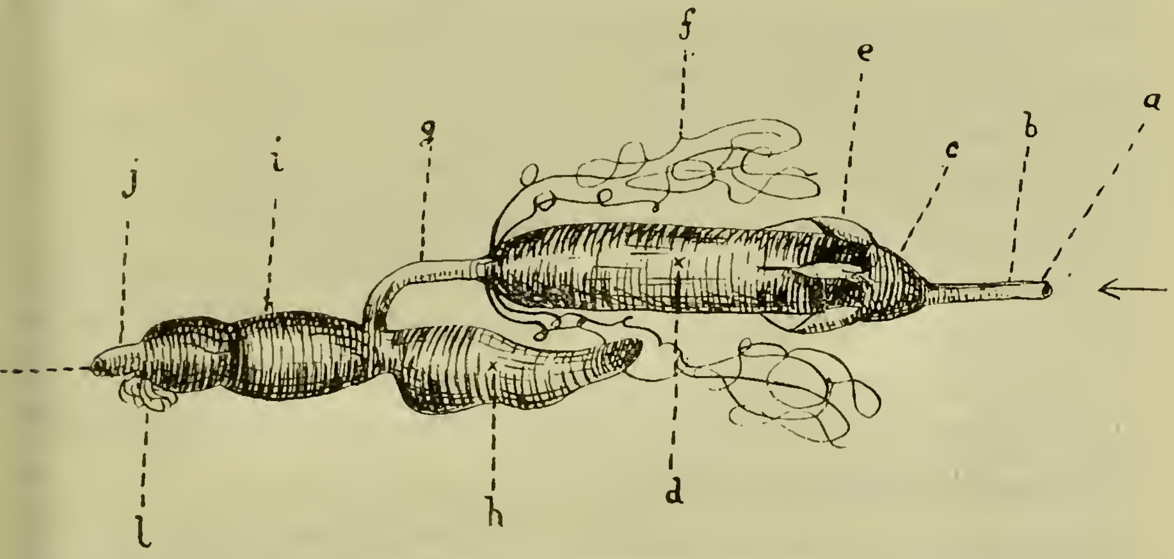

Fig. 67.—Alimentary Canal of Larva (*Tipula paludosa*).

a, Mouth; *b*, gullet; *c*, proventriculus; *e*, cæca; *d*, stomach; *f*, hepatic tubes; *g*, small intestine; *i* and *h*, large intestine; *j*, rectum; *k*, anus; *l*, anal gland.

Insects are classified partly by the structure of the mouth, partly by the structure of the wings, and also by their metamorphosis. Those with biting mouth are called *Mandibulata*; those with sucking and piercing mouths, *Haustellata*. Mandibulata include the Beetles, Grasshoppers, Cockroaches, Ants, Bees, and Wasps. The Butterflies and Moths, Flies, Bugs, and Plant Lice are *Haustellata*. This arrangement is not at all satisfactory, as we get insects in each with a complete and incomplete metamorphosis. All insects may now be grouped in nine orders, as follows :—

1. *Coleoptera*, or Beetles.
2. *Hymenoptera*, or Ants, Bees, Wasps, Sawflies, &c.
3. *Lepidoptera*, or Butterflies and Moths.
4. *Diptera*, or True Flies.
5. *Thysanoptera*, or Thrips.
6. *Hemiptera*, or Bugs and Plant Lice.
7. *Orthoptera*, or Cockroaches and Grasshoppers.
8. *Neuroptera*, or Lace-wing and Caddis Flies.
9. *Aptera*, or Thysanura and Collembola (= Spring-tails, &c.)

The first four orders undergo a complete, the next four an incomplete, metamorphosis. These orders may be distinguished by the following characters :—

Complete metamorphosis :—

Coleoptera—Two pairs of wings, first pair horny (*elytra*). Mandibulate.

Hymenoptera—Two pairs of wings, all of similar texture, first with a dark stigma along the costa. Mandibulate and haustellate.

Lepidoptera—Two pairs of wings covered more or less with scales. Haustellate.

Diptera—One pair of wings only (the first pair). Haustellate.

Incomplete or gradual metamorphosis :—

Thysanoptera—Four narrow fringed wings. Weak suctorial mouth.

Hemiptera—Two pairs of wings, either (i) all transparent, or (ii) the first pair half leathery at the base and transparent at tip (*hemielytra*). Haustellate.

Orthoptera—First pair of wings leathery, with many longitudinal veins; second pair fan-shaped. Mandibulate.

Neuroptera—Two pairs of lace-like wings. Mandibulate.

Scarcely any metamorphosis :—

Aptera—No wings at all. Mandibulate or slightly haustellate.

The above classification is the one now generally adopted, and is followed in the excellent section on Insects by Dr Sharp in 'The Cambridge Natural History.'[1]

COLEOPTERA,

OR BEETLES.

The Coleoptera or Beetles are characterised by possessing four wings. The front pair are horny, and are called elytra; they close over and protect the second pair, which are folded up. The elytra meet in a straight line (suture) down the middle of the abdomen. The larvæ of Coleoptera are of two main types—one typically represented by the wireworm (fig. 78), in which the first three segments have each a pair of jointed legs; the other by the maggot-like grubs of the weevils (fig. 72), which are footless, and usually more or less curved. The body is composed of thirteen segments, including the head. Many, such as the *Cicindelidæ*, have peculiar organs for catching their prey. The pupæ are always inactive. The larvæ feed upon animal life (carnivorous) or vegetable life, and may even be parasitic, as in the *Stylopidæ* found on bees: many also feed upon decaying matter, acting as scavengers (*Necrophagi* or Burying Beetles). The pupæ are sometimes enclosed in a cocoon, the parts of the insect being always distinctly recognisable.

In structure the beetles have the following peculiarities: The mouth consists of an upper lip or labrum, two mandibles, which are hard and horny, two maxillæ with palps, and a movable lower lip or labium, with two jointed labial palpi. The antennæ are very variable in form and the number of segments. The pro-, meso-, and metathorax are all well developed; but when the elytra are closed, only the prothorax is seen, and a small part of the mesothorax called the *scutellum*, which fits between

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[1] Camb. Nat. Hist., vol. v. (Peripatus, Myriapoda, and Insecta), p. 172.

the elytra at their base. The tarsus may have five, four, or three segments, but never more than five; the last one ends in two ungues or claws.

The number of tarsal segments has been made a basis for classification, but such an arrangement is not natural. This classification is as follows:—

1. *Pseudotrimera.*—Tarsi composed of four segments, of which one is very minute, giving the appearance of three-jointed tarsi (*Coccinellidæ*).
2. *Pseudotetramera.*—One segment of the five segments of the tarsi very minute and concealed, giving the appearance of having four segments (*Curculionidæ* and *Chrysomelidæ*).
3. *Heteromera.*—Tarsi of the two anterior pairs of legs with five segments, of the posterior four (*Cantharidæ* and *Tenebrionidæ*).
4. —*Pentamera.*—Tarsi of five segments (*Xylophaga*, *Elateridæ*, *Lamellicornia*, *Carabidæ*, *Cicindelidæ*, &c.)

Lady-birds (Coccinellidæ).

The **Coccinellidæ** or Lady-bird Beetles are nearly all beneficial. Their food consists very largely of plant-lice or Aphidiæ, and the injurious scale-insects or Coccidæ. Both larval and adult lady-birds have the same diet. There are a great number of species, most being black and red or black and yellow in colour. These useful beetles hibernate during the winter months in the adult state, seeking shelter under the bark of trees, in outhouses, or amongst fallen timber, and very often invading houses in such numbers in the autumn as to completely cover the ceilings: this is particularly noticeable to any one living near hop-gardens, where numbers of Coccinellidæ always congregate to feed off the hop-lice.

Perhaps the commonest species are the 2-spotted lady-bird (*Coccinella* (*Adalia*) *bi-punctata*) (fig. 68, 7), the 10-spotted species (*C. decem-punctata*), and the 7-spotted species (*C. septem-punctata*) (fig. 68, 9), which may be found all over England. The eyed lady-bird (*C. ocellata*), one of our largest species, may also be often seen in hop-gardens, and feeding off the larch and other coniferous plant-lice. This species can be told from the other large ones by the eight black spots on the elytra being surrounded with a yellowish band. The genus *Scymnus*, another group of Coccinellidæ, also do much good by devouring scales. A minute black lady-bird (*Scymnus minimus*) has been recorded by Miss Ormerod as feeding on plant-lice and red-spiders as well. These useful beetles lay their creamy-white eggs (1) in the spring upon a variety of plants. They are deposited in groups closely applied together, and hatch out into the larvæ in from ten to fifteen days. The larvæ, called "niggers" (3 and 4), are smoky black or grey, with yellow or orange and white markings on their bodies. They are extremely active, and pursue the plant-lice with considerable agility. The "nigger" has six jointed legs in front, and the surface of the body is more or less rough, and slightly hairy. When mature these beneficial creatures attach themselves by their tail with silk to the under-side of a leaf, and then change into the short, plump, black and creamy-white pupa (5 and 6): in the early

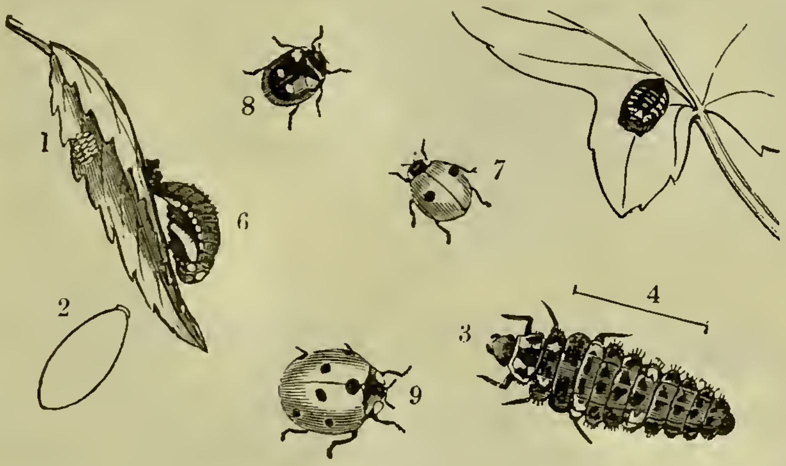

FIG. 68.—LADY-BIRDS (*Coccinellidæ*).

1, Ova on leaf; 2, egg magnified; 3, larva ("nigger"); 4, natural size; 5, 6, pupæ; 7, Adalia bi-punctata; 8, variety of A. bi-punctata; 9, Coccinella septem-punctata. (Curtis.)

summer the pupa hatches out in about two weeks into the mature lady-bird, which soon commences to carry on the good work of clearing off the fly, started during its larval career.

The importance of these insectivorous allies cannot be overestimated. The destructive scale, *Icerya purchasi*, which all but annihilated the orange-groves of California, has been checked, and almost destroyed, by the importation into America of the lady-bird (*Vedalia cardinalis*) which feeds upon that scale in Australia. Some lady-birds of the genus *Epilachna* do much harm by eating leafage of plants in Africa, America, &c. These destructive lady-birds can be told by having pubescent wing cases.

The Pseudotetramera contain the following important injurious species :—

The Turnip Flea-beetle (Phyllotreta nemorum).

The Turnip Fleas or Fly, as they are popularly called, belong to the family **Halticidæ**. These Flea-beetles are small insects with enlarged posterior femora, and feed upon a great variety of plants. Several species may be found on root-crops, especially turnips, namely *P. nemorum*, *P. cruciferæ*, and *Plectroscelis concinna*. The latter is generally termed the Hop Flea, on account of the harm it does to the hopbine. The Turnip Flea (*P. nemorum*) is a small beetle, about one-twelfth of an inch in length ; its wing-covers or elytra are shiny black, each having a clear yellow stripe running down the middle and bending round at the end. They are called Flea-beetles because they have the same saltatorial habits as those nimble degenerate flies from which they take their name. The adult insects hibernate, and on the first warm days of spring come forth to get ready for their ravages upon the turnips and other cultivated Cruciferæ when they come above-ground. The winter hibernators at first-feed upon charlock and other cruciferous weeds, such as

Shepherd's purse and Jack-by-the-hedge; but as soon as the turnips show above-ground, away they fly and nip off the two cotyledons just below their junction, thus completely destroying the young plant. Should the weather be warm and dry, the damage they do is tremendous, often necessitating two or more sowings of seed before a plant can be obtained. They are very susceptible to damp and cold, and then become sluggish,—a feature usually noticed early in the morning after a heavy dew. When the turnips get into rough leaf the damage they do is not so great; but even then they are destructive, eating away at the tissues until the leaves are almost skeletons. The female lays her eggs upon the turnip leaf, on the rough under-surface, often choosing a place near the ribs to deposit them. In from four to six days the ova hatch into minute larvæ with large brown heads and biting jaws, six small jointed legs in front, and a number of hairs over the body. The larvæ at once burrow into the middle of the turnip leaf, and there tunnel about in the parenchyma for six or seven days, when they attain their fully fed state, being about one-sixth of an inch long. On reaching maturity they leave the leaf and

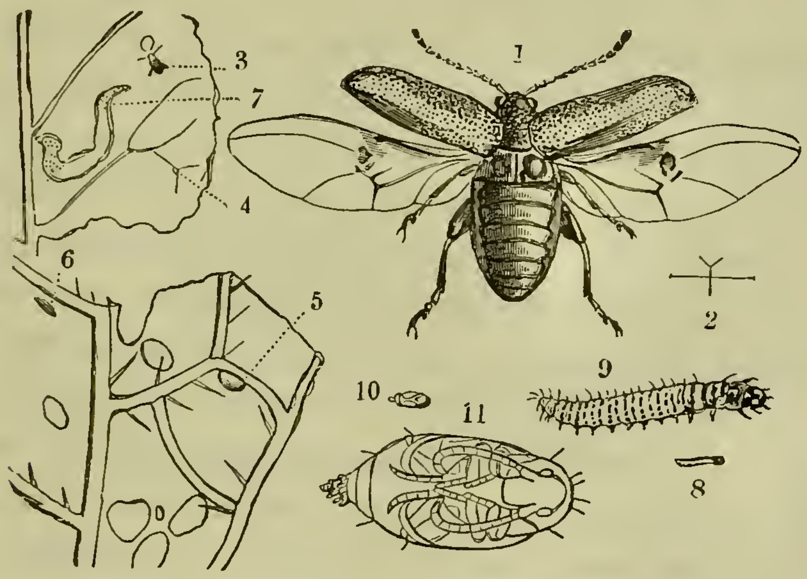

Fig. 69.—1, The Turnip Flea Beetle, much magnified; 2, nat. length and wing expanse; 3, nat. size; 4, 5, egg, nat. size and mag.; 6, 7, mine, and cuticle eaten away by larva; 8, 9, larva, nat. size and mag.; 10, 11, pupa, nat. size and mag.

fall to the ground, where they pupate just under the soil. The pupa is a pale-coloured body, with the parts of the future flea-beetle marked out upon it. In this position they remain ten days, when the mature beetle appears. There are a great number of broods during the year, the last or winter brood hibernating in all manner of places,—beneath stones, amongst the rough grass of the headlands, in the hedgerows, and wherever else they can get shelter. Cabbage, thousand-headed kale, broccoli—in fact, all cultivated and wild Cruciferæ—are alike attacked.

Prevention and Remedies.—There are some hundreds of ways recorded of preventing and destroying this pest, but for all practical purposes they can be reduced to some half a dozen methods. Needless to say, the state of the land and the weather affect this pest very much. If plants can be got into the rough leaf there is little fear of any great loss; good cultivation therefore helps to keep down the damage. Where we are subject to the fly, steeping the seed in kerosene or paraffin is very often successful, especially if germination is rapid.[1] The smell remains on the seed when it is pushed up above-ground and wards off the fly: a great number of farmers find this plan very beneficial. When we see the fly commencing to destroy we can also keep them off to some extent by broadcasting over the young plants, *early in the morning when the dew is on the leaf*, soot, lime, and road-dust mixed in equal quantities. This compound sticks to the young leaves and drives the fly off for some time; a dressing of superphosphate at the same time would push the growth on, and so get the plant out of the young and vulnerable stage. Those who have a "strawsoniser" cannot do better than run the machine over the young plants directly they are up, spraying them with pure paraffin at the rate of 1½ to 2 gallons to the acre. The destruction of all winter shelter should also be paid attention to.

[1] Turpentine has also been used with excellent results.

THE HOP-FLEA (PLECTROSCELIS CONCINNA).

Very often in the early part of the year the hop-shoots are much eaten away by this flea-beetle, which also goes to the turnips. The hop-flea does most damage in warm days when the nights have been cold, checking the growth of bine. It also eats the leaves in the same way as the turnip-flea, and occasionally even attacks the cones themselves, when the damage of course is irreparable. The larvæ are found in the hop-leaf and the pupæ in the hills, the life-history being similar to *P. nemorum*. Great numbers of *P. concinna* hibernate in broken pieces of bine, in the bine-stumps left in the ground, and, like the turnip-flea, in hedgerows and other shelter. *P. concinna* is a brassy-coloured flea-beetle. Spraying the young bine with paraffin emulsion keeps the flea-beetles off for a time, whilst a good dressing of soot and lime over the hills in the early morning before the beetles are about will keep the pest in check, but the best plan is to jar the beetles off on to tarred boards and to keep poultry in the hop gardens.

An allied beetle, *Psylliodes attenuatus*, sometimes quite ruins hops in an advanced state in Kent by riddling the cones and leaves, when the former are beginning to ripen.

THE CABBAGE-FLEA (PHYLLOTRETA CRUCIFERÆ).

mainly attacks cabbages, sprouts, kale, and savoys, but it also joins with the turnip-flea in attacking turnips and swedes. It is deep shiny blue in colour, and when attacking cabbages feeds on the upper epidermis and soft tissues beneath, leaving the lower epidermis intact, thus giving the plants a marked pale blotchy appearance. It has been found that this and other allied flea-beetles which attack cabbage may be controlled to some extent by spraying with arsenate of lead. Several species appear to work in a similar manner.

MUSTARD-BEETLE (PHÆDON BETULÆ).

The Mustard-beetle or Black-jack often destroys turnip, rape, and mustard to an alarming extent, especially in the Fen districts, where it attacks both white and brown mustard. It is where mustard is grown for seed that it makes its effects chiefly felt. The Mustard-beetle belongs to the family *Chrysomelidæ*, which contains many injurious species. In length the Black-jack is about 1½ to 2 lines long, oval in form, and deep-blue to dark-green in colour, with black legs and antennæ. The females come out in the spring, having hibernated during the winter under grasses and in the dead hollow stems of plants, and at once lay their eggs on the leaves of Cruciferæ, where the larvæ feed off the leaves for a few days and then pupate in the soil beneath, then in two weeks a new brood appears. The larvæ are dusky-yellow in colour and spotted, with six legs and a caudal foot, and are about $\frac{1}{5}$ to $\frac{1}{4}$ of an inch long: there is a set of tubercles along each side, from which the larvæ can protrude yellow glands.

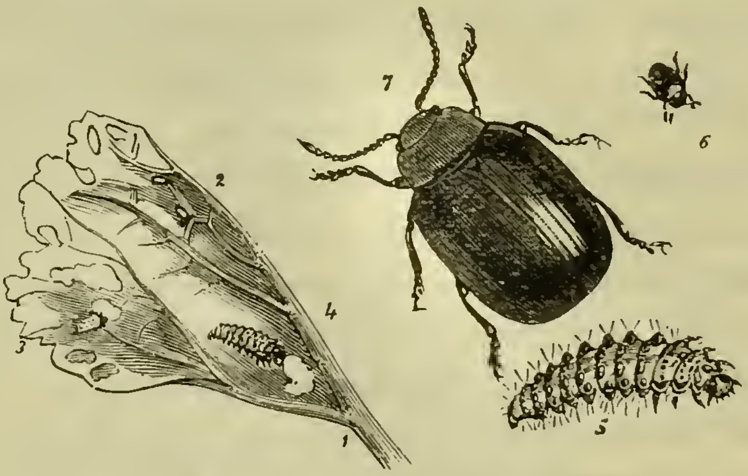

FIG. 70.—MUSTARD-BEETLE (*Phædon betulæ*).

1, Attacked leaf; 2, ova; 3, 4, 5, larvæ, nat. size, and magnified; 5 and 7, imago, nat. size, and magnified. (Curtis.)

Prevention and Remedies.—Destruction of the stems of mustard, &c., by deep ploughing, so as to bury the beetles that hibernate in the stalks. Keeping clean the sides of all waterways, where numbers of the beetles hibernate in the hollow reeds, &c. It is advisable to stop growing mustard for a couple of years where the beetle is present; this will be found to lessen their numbers rapidly, and also cabbage-crops must be given up for the year. Various dressings on the young plants to destroy the first brood are advantageously applied as for turnip-flea. These beetles migrate in a body, and thus can be stopped going from field to field by cutting a small trench across their line of march and filling it with tar. Although they are winged, they seem to use their wings little when doing the damage. A beetle, *Saprinus virescens*, one of the Histeridæ, feeds off the larvæ of the Mustard-beetle, and mimics that insect in appearance so closely that only a practised eye can separate them.

Two other beetles attack mustard—namely, the Blossom-beetle (*Meligethes æneus*), much smaller than *Phædon betulæ*, which eats the flowers, and the turnip-weevil (*Ceutorhynchus assimilis*), a grey long-snouted species which lays its eggs in the mustard and turnip seed-pods.

ASPARAGUS-BEETLE (CRIOCERIS ASPARAGI).

The Asparagus-beetle is well known in gardens in the South of England, and often does a great deal of harm to asparagus-shoots and also to the seed-heads. It is a dark bluish-green beetle, with a rusty-red thorax, yellow patches on the elytra and red edges to them. In length *C. asparagi* is about $\frac{1}{4}$ of an inch. It belongs to the group of beetles called Eupoda, and therefore is in the same group as the Chrysomelidæ. The insects hibernate under rubbish or loose bark, and come out from the middle to end of April or May, soon laying their large, elongate-oval, dark-brown eggs on the fronds in rows of three or four: in from four to ten days these hatch into dirty olive-green-coloured larvæ, with six black legs and a pair of foot-like tubercles on each segment, and an anal pair by which they hold firmly to the plant. Like many Chrysomelidæ, they can exude out of the mouth a drop of black fluid on being touched. In two weeks they are full fed and fall to the ground, where they form a cell and pupate. The yellow pupa gives rise to the beetle in from five (Chittenden) to ten days (Miss Ormerod says from two to three weeks), and the beetle lays her eggs on the feathery fronds of the asparagus in rows, sticking them on by their ends.

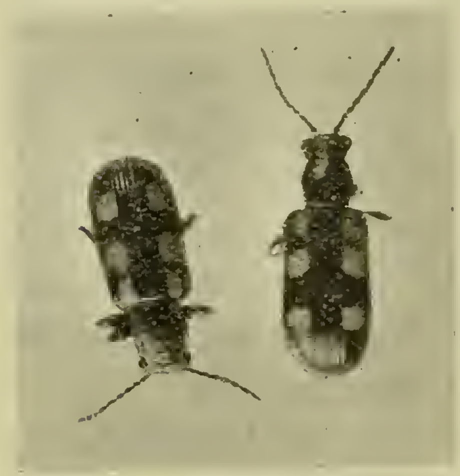

FIG. 71.—THE ASPARAGUS-BEETLE. Enlarged 3 times.

Prevention and Remedies.—Neither chickens nor ducks eat asparagus, and thus can be turned on the beds that are infested, and will then soon clear off these pests. "An excellent practice among prominent growers [in America] is to cut down all plants, including seedlings and volunteer growth, in early spring, so as to force the parent beetles to deposit their eggs upon new shoots, which are then cut every few days before the eggs have time to hatch for the first new brood."—(Chittenden.) Fresh air-slaked lime dusted over the plants early in the morning soon kills the larvæ, but by far the best plan is to spray the fronds with arsenate of lead paste.

The **Curculionidæ**, or Rhynchophora, the family of Weevils, are destructive to crops, fruit, seed, and stored goods. The weevils are a very extensive group of beetles, in which the head is more or less prolonged into a snout or rostrum upon which the elbowed antennæ are placed. There are two chief sub-families, the *Curculionidæ* and the *Bruchidæ*—the former having elbowed antennæ, the latter straight. Weevils are all vegetable-feeders. The larvæ are footless grubs, which are creamy-white, curved, and wrinkled, and generally sparsely covered with pale hairs. The head is provided with a biting mouth, and is brown in colour. We find them living in galls, seeds, buds, blossoms, fruit, and on the roots of plants. The following are very injurious species:—

THE APPLE-BLOSSOM WEEVIL (ANTHONOMUS POMORUM).

This weevil is a serious apple pest in the midland, southern, and south-eastern counties, but occurs in many other parts. The adult beetle, which is reddish-grey, with a V-shaped pale mark on the elytra and with a longish curved proboscis, is about one-fourth of an inch in length. They hibernate in the adult condition under the bark of apple and other trees, &c., coming out in the spring about the time the blossom-buds are commencing to expand. The female then bores a hole into the expanding bud by means of her rostrum, which has a pair of sharp biting mandibles at the tip, and then deposits an egg or eggs in the hole she has formed. The maggots hatched from the ova remain feeding in the blossoms, which do not open (fig. 73, ii), and which soon become brown and withered, and readily shake off and fall to the ground, so called "Capped" blossom. Pupation takes place in the dead blossom, the weevil eating its way out when mature. Usually the blossoms do not

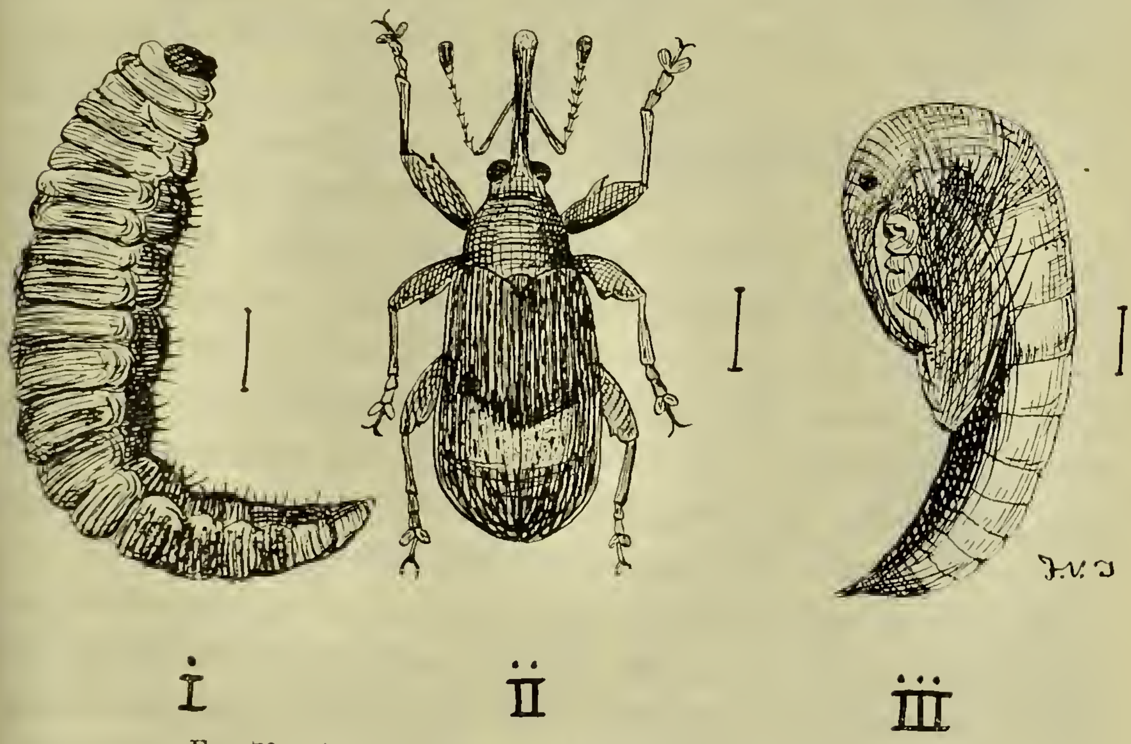

FIG. 72.—APPLE-BLOSSOM WEEVIL (*Anthonomus pomorum*).
i, Larva; ii, adult; iii, pupa.

fall until after the weevils have escaped: a small round hole shows the place of exit of each beetle (fig. 73, i). The female takes some time to lay her eggs, each one requiring about three-quarters of an hour to oviposit in a single bud. As they can only live in an unopened blossom, the attack must necessarily be of short duration. The worst mischief is wrought when we have cold nights and bad weather, thus retarding the opening of the buds and giving a longer period for oviposition. The whole life-cycle is complete in about five weeks. There is only one brood in the year. The adult beetles coming from the diseased blossoms feed upon the apple leafage until the time arrives to hibernate. The males are endowed with considerable powers of flight, but one seldom finds the females on the wing. The majority crawl up the trees to lay their eggs.

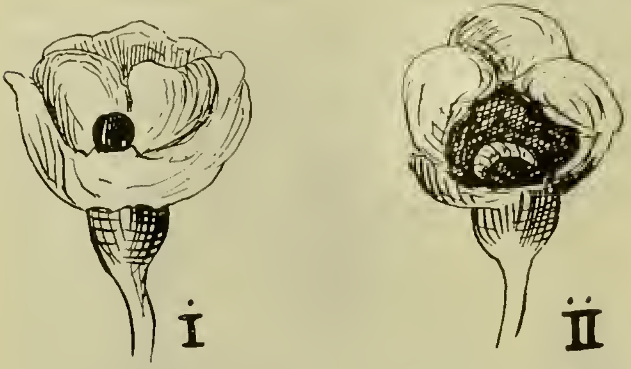

Fig. 73.—Apple Blossoms damaged by Apple Weevil (*Anthonomus pomorum*).

Prevention and Remedies.—The same rules for prevention of this fruit pest apply to all alike—namely, the destruction of winter shelter by keeping the tree trunks clean and free from rough bark. Trees which are seen to be badly infested, where possible, should be well shaken, and the dead blossoms collected and burnt before the beetles have escaped. The adults may also be jarred off the trees on to cloths and destroyed.

Pea and Bean Weevils (Sitones lineatus and S. crinitus).

That sparrows do an immense amount of harm is only too well known, but they are not accountable for the damage done to young peas and beans that is usually attributed to them. When the edges of the leaves of our peas and beans are eaten out in notches, it is generally said to be due to this cosmopolitan bird; but if we carefully and quietly watch a row showing these symptoms, we will observe, sitting on the edge of the leaf, a clay-coloured beetle: this insect is one of the Pea and Bean Weevils, either *Sitones lineatus* or *S. crinitus.* These beetles are about one-fourth of an inch in length, the former having three dark longitudinal strips on the thorax, the latter somewhat larger and clay-coloured all over. Like the other weevil described, they hibernate as adults; but they are also found in the larval state in winter. The hibernators come out on the wing the first warm days in spring, and feed off clover, lucern, and trifolium, as well as peas and beans. It is especially the last two that they damage by eating away the leaves, taking large notches out of them. These sitones are most timid: directly they hear a sound, or feel the least movement, they fall to the ground on their backs, and remain as if dead. Feigning death is a common habit amongst weevils. The larvæ live in summer at the roots of peas and beans, and often do some damage to them. They mature before the end of summer, the adults from them laying their eggs upon the roots of clover, where the white, footless, curved grubs remain feeding throughout the winter, and very frequently kill the clover. The adults which hibernate pass the winter in all manner of places. They have been noticed in numbers in barley stubble: I have seen them in great quantities in corn-stacks, and in a variety of other places. Field peas often suffer very severely, as well as garden produce.

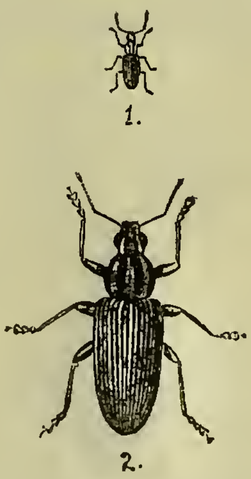

FIG. 74.—PEA WEEVIL (*Sitones lineatus*), nat. size, and magnified. (Whitehead.)

Prevention and Remedies.—The destruction of all winter shelter is essential. When field peas are attacked, a light rolling does much good, followed by a dressing of soot: the soot annoys them, and when lying on their backs on the ground, a light roller destroys a great number, besides breaking down the ground, and so doing away with the shelter they get in inclement weather from the rough clods of earth. The larvæ on the roots of peas can easily be killed in gardens by watering with soluble phrenyl. In gardens it is a good plan to spread fine earth along the rows of peas.

OTIORHYNCHUS WEEVILS.

Amongst other destructive Weevils we may mention the Raspberry or the Clay-coloured Weevil (*Otiorhynchus picipes*), the Strawberry or Vine Weevil (*O. sulcatus*), and the Plum or Red-Legged Weevils (*O. tenebricosus* and *fuscipes*). The genus *Otiorhynchus* is characterised by possessing no wings; the elytra are soldered together over the abdomen. They are mostly large beetles, with a distinct short rostrum and elbowed antennæ. Both adults and larvæ are very destructive to fruit, &c.; the former devour the leaves and blossom, and later feed off the roots. All the species mentioned here are night-feeders, hiding away during the daytime beneath clods of earth, boards, under the leaves of plants, or in crevices of walls. They fall to the ground from the fruit-trees and bushes at the least shock or sight of a light, and can thus be easily caught by holding tarred boards beneath the trees and then jarring them. In this way the Raspberry Weevil (*O. picipes*) has been successfully cleared out in many of the fruit-gardens in Cornwall and elsewhere, a similar plan being equally successful for catching the other species. The larvæ are of typical weevil form, and live on the roots of strawberries, currants, and other fruit, and on ferns and pot plants, during the winter months, often doing much damage.

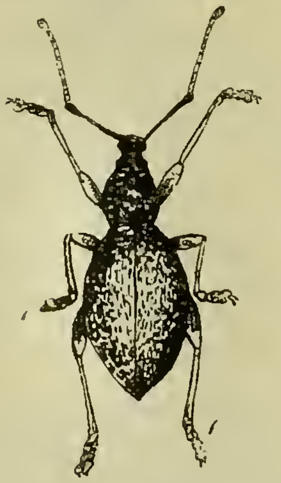

FIG. 75.—RED-LEGGED WEEVIL (*Otiorhynchus tenebricosus*). Twice nat. size.

Other destructive weevils are the Nut Weevil (*Balaninus* *nucus*), a large weevil with extremely long rostrum, which causes the maggot in cob and filbert nuts; the Turnip-Gall Weevil (*Ceutorhynchus sulcicollis*), producing the large galls we find on turnips, containing a white larva in the winter; the

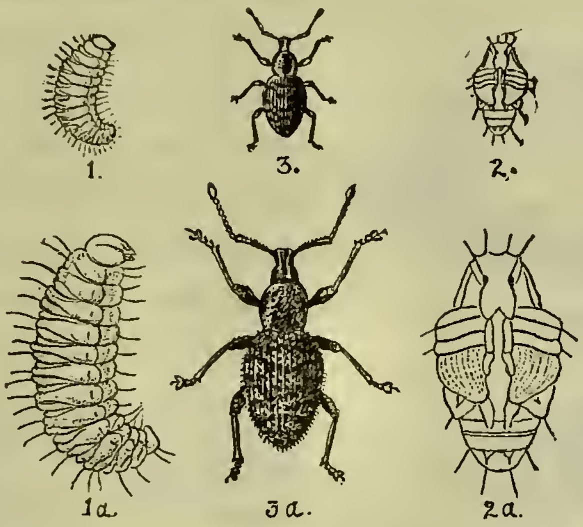

FIG. 76.—THE RASPBERRY WEEVIL (*Otiorhynchus picipes*).
1, 1*a*, Larva; 2, 2*a*, pupa; 3, 3*a*, weevil; natural size, and magnified.

Clover Weevil (*Apion apricans*), a small bluish weevil with red legs and a very long snout; the Pine Weevil (*Hylobius abietis*), which devours the shoots of the pines and other conifers; and the Corn and Rice Weevils (*Calandra granaria* and *C. oryzæ*), which deposit their eggs in stored wheat, barley, oats, and rice.

PULSE-SEED WEEVILS (BRUCHIDÆ).

The Bruchidæ belong to the second group of weevils, which have a short rostrum and straight antennæ. They are mostly brownish-red beetles with broad bodies and small in size, seldom more than one-sixth of an inch in length. *Bruchus rufimanus* is one of the commonest. The female deposits her eggs in the developing bean-pod. The larva lives inside the bean and there pupates, remaining inside the seed throughout the winter. Infested seed can always be told by a small round depression on one side. On breaking through the thin skin that covers it, the larva or pupa will be found in a cavity inside the seed. The beetle hatches some days before it makes its exit, which it does through the round depression just referred to. A distinct hole is then seen in the seed, from which the beetle has escaped. Such infested seed germinates, but does not produce a healthy plant. Often the seed is sown before the Bruchi have hatched, and thus they will be in a good position to continue their attack upon the crop again. Infested seed should never be purchased; but if it is, it should be subjected to either of the following methods of treatment—namely, fumigation by bisulphide of carbon or soaking in carbolic water. The infested seeds may be placed in a closed box and a saucer of the carbon bisulphide placed on them and left for a few hours: the fumes pass down and penetrate the seeds, killing not only larvæ, but pupæ and adults also. Many kinds of Bruchidæ attack pulse of all kinds.

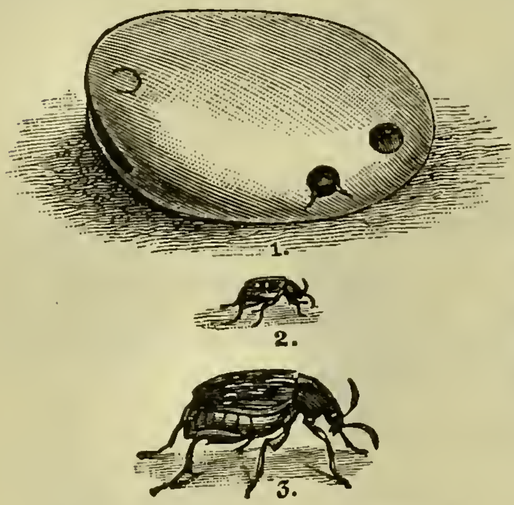

Fig. 77.—Bean Beetle (*Bruchus rufimanus*).

1, Infested bean; 2 and 3, beetle, nat. size, and magnified. (Whitehead.)

The Pentamera form the largest division of beetles, and include a great number of destructive species. The most important family of them economically is that of the

Click-beetles (Elateridæ).

The **Elaters** are commonly called Click-beetles or Skip-jacks, on account of their peculiar skipping movements, and the curious sharp clicking noise they produce. They are the parents of the dreaded Wireworm, by far the most obnoxious farm and garden pest. The elaters have an elongated body. There is a spine upon the venter of the prothorax, which fits into a corresponding pit on the mesothorax. When the beetle falls on its back, it is unable to regain its normal position with its short legs, but the spine apparatus enables it to do so. The beetle, to regain its feet, arches the head and prothorax and abdomen, so that the spine is brought out of the mesothoracic pit; suddenly relaxing its muscles, the body flies back, and the spine coming violently in contact with the mesothorax, jerks the insect into the air, and at the same time produces the clicking noise, the beetle sooner or later falling down on its ventral surface. The hind angles of the prothorax are often produced into spines.

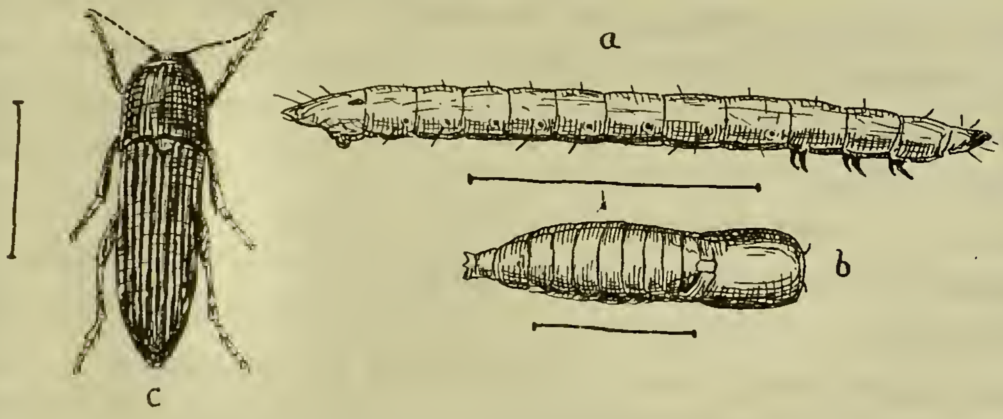

FIG. 78.—STRIPED CLICK-BEETLE (*Agriotes lineatus*).
a, Wireworm; *b*, pupa; *c*, imago.

There are several species of elaters that are very destructive in their wireworm or larval state in Britain. The commonest is *Agriotes lineatus* or the Striped Click-beetle (fig. 78, *c*), an insect about half an inch long, with pale stripes down the reddish-brown elytra. *Athöus hæmorrhoidalis* is also sometimes very abundant, and smaller than the former.

The life-history of the Click-beetles is as follows. The adult beetles appear from April to October,[1] but the majority are noticed in June: they may be found settled low down upon grass during the day, but towards evening on the tops of herbage, or may be taken in abundance by sweeping a net over clover. They lay their eggs close upon the ground, for

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[1] Now and then these beetles may be found in the winter.

preference, wherever there is plenty of shelter, such as at the base of clover, grass, and weeds. The eggs soon give rise to young wireworm, which are at first white, but which gradually become shiny yellowish, yellowish-brown, or even brown in colour. Wireworm have an extremely tough skin, and are provided with a very powerful mouth ; the first three segments have each a pair of jointed legs, and there is also a fleshy swelling beneath the anal segment ; in addition there are a few hairs scattered over the surface. When full grown a wireworm may reach the length of about an inch to over an inch, depending upon the species. They take at least three years to mature, and in many instances four or even five, especially if food is scarce. They live almost entirely underground, upon the roots of plants. During winter they cease feeding if the weather is severe ; but if the winter is open they may feed all the time. When full-grown they burrow deep into the earth and pupate, this change apparently taking place in the autumn ; in the following spring or early summer the adult beetle escapes from the ground.

Nearly all plants are devoured by wireworm, with the exception of mustard, which they will not touch. Flax is also said to be exempt from their attack. They feed very ravenously, and destroy far more than they can devour, hence the great damage caused by them. Permanent pasture and clover ley contain the greatest number of these pests, as they can there work without being molested. Serious attacks of this larva usually follow the breaking-up of pasture and clover leys, unless the land is to some extent freed of these vermin first.

Prevention and Remedies.—When land is going to be broken up, it is well to feed it down with sheep, and then feed them artificially on it. By so doing all the available herbage is cleared off, the land is trodden down firm, preventing the wireworm from moving and made objectionable by the sheep's excrement. This process places the pests under unfavourable conditions. On breaking the land up a dressing of gas-lime is beneficial, if applied in a proper manner. Vaporite also tends to check them. Mustard is never touched by these larvæ, and thus may be advantageously employed as a green manure. It should be let grow to about a foot high, and then either ploughed in direct or partly fed off by sheep, and then turned in: excellent results follow this method. As wireworm move about in the soil from plant to plant, frequent and heavy rollings with a Cambridge ring-roller cannot fail to give relief: in attacks upon wheat and barley this is the best method, followed by a good dressing of artificial manure to force on growth and repair the damage. The destruction of all weed growths, particularly couch-grass, is highly necessary; wireworm are most destructive on badly farmed and unclean land. I know of no manures, unless it be seaweed, deleterious to them. Mustard dross has been said to have good results in driving them away, but experiments in the laboratory and on the farm do not bear out this statement. In garden cultivation the use of bisulphide of carbon and trapping with carrots and pieces of mangolds may be resorted to with good effects. An excellent plan is to drill the artificial manures *with* the seed; this keeps the wireworm off for some time and allows the plants to grow away. The value of the rook and other birds is considered in a later chapter.

The Lamellicornia or Cockchafers.

The Rose (fig. 79) and Stag Beetles also belong here. The Cockchafers are called **Melolonthidæ**, and have a peculiar form of antenna. The common Cockchafer (*Melolontha vulgaris*), fig. 80, a large beetle about an inch long, with brown elytra, having five ridges running down them, and pointed abdomen with black and white alternately down the sides, is often very destructive in both adult and larval stages. The antennæ have seven curious leaf-like lamellæ in the male (E) and six (F) in the female. The larvæ (C) are large, white, soft grubs, often over two inches in length, the end of the body swollen into a large sac, with a large, brown, horny head, and six almost useless legs in front. They live for two years, feeding on the roots of plants and young trees, and pupate deep in the earth in a well-formed cell in the third summer. The chafers hatch out some time before they come above ground. Other allied injurious species are the Garden chafer (*Phyllopertha horticola*) and the Small or Summer chafer (*Rhizotrogus solstitialis*).

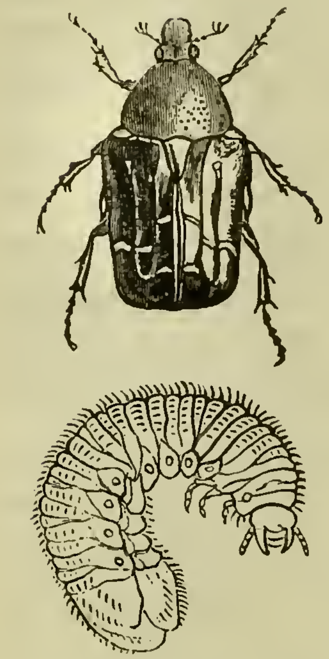

FIG. 79.—ROSE BEETLE (*Cetonia aurata*), and larva. (Nicholson.)

Prevention and Remedies. — These destructive beetles often may be collected in great numbers by shaking them off the trees over tarred cloths, and then burning them or giving them to pigs, which greedily devour them. Where land is infested with cockchafer grubs, a good plan of clearing them out is to turn *pigs* into the field when it is being ploughed: these animals grub about

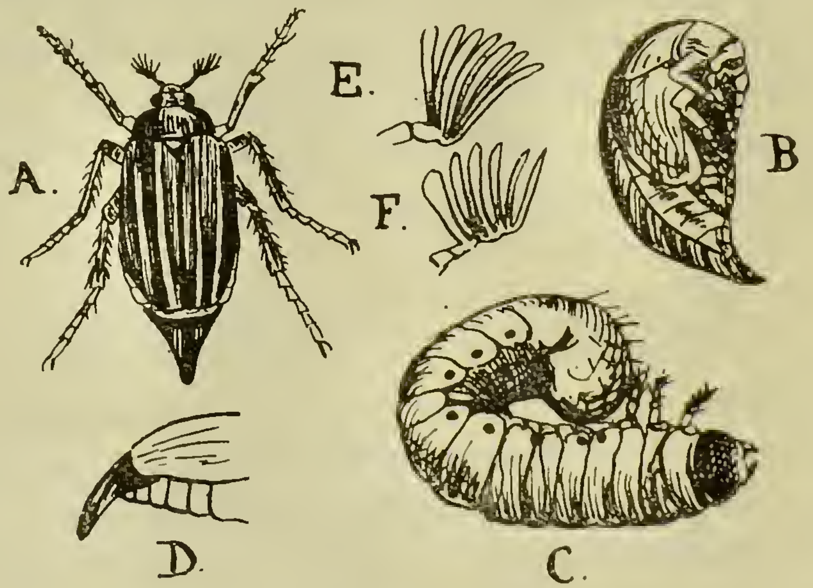

FIG. 80.—COCKCHAFER (*Melolontha vulgaris*).

A, Imago; B, pupa; C, larva; D, tail of ♀; E, antenna of ♂; F, antenna of ♀. (A, B, and C slightly reduced.)

for the white larvæ and devour them wholesale. Dressings of vaporite soon kill them. The encouragement of birds such as rooks and starlings is advisable.

The **Necrophaga** (or **Clavicornia**) are mostly "scavengers," feeding on decaying animal and vegetable refuse. One family, the *Dermestidæ*, are very destructive: they are small grey or brown beetles, that do much damage to manufactured animal matters in their larval condition. A small dark-brown beetle with fawn-coloured bases to the elytra and three dark spots, known as the Bacon Beetle (*Dermestes lardarius*), does much mischief in its curious larval state. The larva is dark-brown, and covered with tufts of hair, which are placed regularly on the margins of each segment. They feed upon furs, hides, hams, and bacon.

The curious Sexton or Burying Beetles (**Necrophorus**) belong to the family *Silphidæ*, which also contains the injurious Beet Carrion-beetle (*Silpha opaca*). Some of the commoner Necrophori may be found everywhere, pretty beetles with red and black elytra. They bury any dead bird or small mammal they find, as deep as they can in the soil, and there deposit their eggs. The larvæ feed off the decaying body, and thus rid the air of impure gases.

THE BEET CARRION-BEETLES (SILPHA OPACA AND S. ATRATA).

These beetles have become a regular mangold pest. Originally they were scavengers, feeding on dead carcasses of birds and mammals as they lay on the ground; but the larvæ now feed upon the leaves of the mangold, and have done so since at least 1844, when Curtis reports an attack of these beetles, since which time numerous attacks have been reported. There are two species that do the harm—*S. opaca* and *S. atrata;* the former is very destructive to sugar-beets in France. *S. opaca* is nearly half an inch long, flattish in shape, dark-brown in colour, and when fresh, covered with a reddish-brown down, which rubs off, when the elytra appear black; each elytron has three sharp ridges running along it, and between the second and third ridges is a dark spot; the edges of the wing-shields are turned up, the tip of abdomen tawny-red. *S. atrata* is also common: it is a black and shiny species without the ridges on the wing-cases. We find the beetles under dead animals and birds in the spring, and in the winter amongst moss and under stones and wood. The female lays her eggs on manure, decaying leaves, and on the ground; in two weeks the larvæ appear, and feed off the wurzel for about three weeks, when they pass into the soil and form a cell in which they pupate; the adult beetles come out in about eighteen days. There are two broods in the year. The larvæ are two-fifths of an inch long, and have six feet and two anal spines, and the sides of the segments pointed; in colour brownish-black except the sides, which are yellowish-grey.

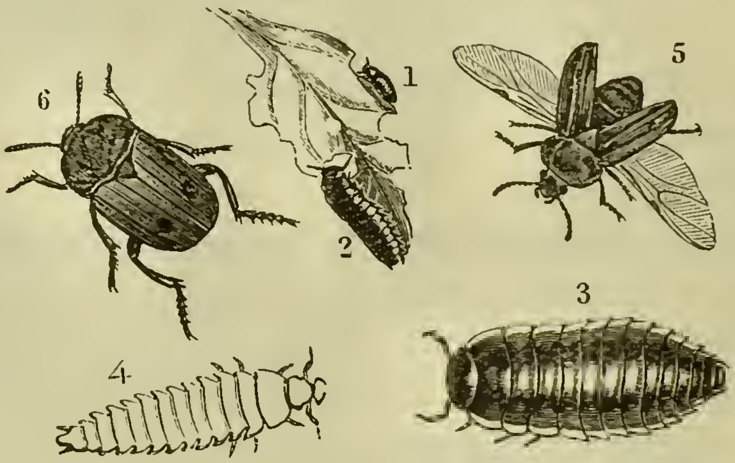

Fig. 81.—Beet Carrion-beetle (*Silpha opaca*).

1 and 2, Larvæ, natural size; 3 and 4, different stages of larvæ, enlarged; 5, female; 6, male. (Curtis.)

Prevention and Remedies.—As the beetles breed in manure, it should be ploughed in at once on wurzel land where the pest occurs. The beetles may be trapped by placing a freshly flayed sheepskin on the ground here and there.

THE RASPBERRY BEETLES (BYTURUS TOMENTOSUS).

Of all Raspberry pests the so-called Raspberry Bug, the *Byturus tomentosus*, is the most noxious. The beetle (fig. 82) is about one-sixth of an inch long, brown in colour, with a dense golden-brown pubescence. It belongs to the *Nitidulidæ*, the same family that contains the Mustard Blossom Beetle. We notice these beetles at their work in May upon the canes, eating the flower-buds at their base. The females deposit their eggs singly in the fruit-buds, and from these come the larvæ at about the time the fruit is formed, which at once commence feeding upon it and thus spoil it entirely or reduce it in size. This grub, which we often eat in the fruit, is yellowish, with brown marks in the middle of each segment, and about one-third of an inch in length; at the tail end are two curved projecting points. It mainly lives in the receptacle of the fruit. When mature it falls to the ground or gets into the

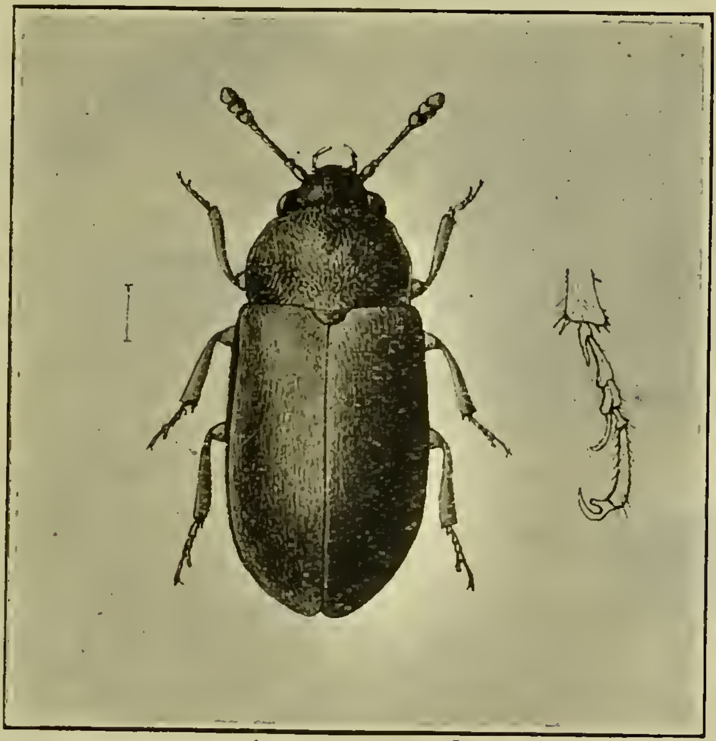

FIG. 82.—THE RASPBERRY BEETLE (*Byturus tomentosus*).

holes in the canes and poles, and there pupates and remains all the winter.

Prevention and Remedies.—Autumn application of vaporite round the canes and the destruction of prunings is about all we can do to prevent a recurrence of this attack. Where we see numbers in the plantations, in May, we can clear them off by jarring over tarred boards or, better, by shaking into tins of paraffin. It also attacks the Loganberry and Blackberry.

GROUND-BEETLES OR CARABIDÆ.

The Ground-beetles or **Carabidæ** are a very extensive family. These beetles belong to a division called Geodephaga, and may be identified by their hard convex elytra, long thin legs and antennæ, and their extremely active habits. The majority are carnivorous, and do good by devouring noxious insects, molluscs, and animal matter. The mouth is armed with large scissor-shaped mandibles, with which they cause great havoc amongst insect life. Some have wings, others have none. The larvæ of Carabidæ are elongated and flat, slightly fleshy, with a hard chitinous head and first segment: three pairs of legs on the first three segments, and two horn-like appendages on the dorsum of the tail segment, sometimes an elongated process below: like the adult, the larvæ have powerful scissor-like jaws. These larvæ are carnivorous, and have a similar diet to the adult. The two most commonly met with are the Garden Ground-beetle (*Carabus violaceus*) (fig. 83) and *C. nemoralis.* The former is a large purple beetle, often seen actively running about fields and gardens; the latter is golden-bronze in colour. Both are predaceous, and so are the majority of this family; but some have developed injurious vegetarian habits, attacking corn and strawberries to a disastrous extent.

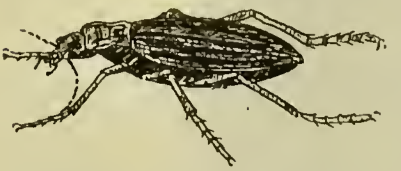

FIG. 83.—GROUND-BEETLE (*Carabus violaceus*). Reduced $\frac{1}{3}$.

The Corn Ground-beetle (*Zabrus gibbus*) (fig. 84) injures the roots of corn in its larval state; the adult destroys the barley in the ear, and lives during the day in tunnels in the ground. They are black-coloured beetles, about an inch in length, with broad heads and strong biting jaws. Another species, *Steropus madidus*, somewhat smaller, devours mangel-wurzel, attacking the young roots, often gnawing them off at the level of the ground. This beetle is also carnivorous. The same species and two others—*Harpalus ruficornis* and *Calathus cisteloides*—have in recent years been working among strawberries. *H. ruficornis*, the most abundant, is about two-thirds of an inch long, black, with a large thorax, the elytra protecting two wings. The other two noticed have no wings. They not only strip the ripe and ripening fruit but attack the leaves and shoots. All we can do in regard to such an attack is to trap the beetles by sinking jam-pots or small pudding-basins in the soil, partly filled with sugar-water and decaying meat. The beetles fall in and are thus caught.

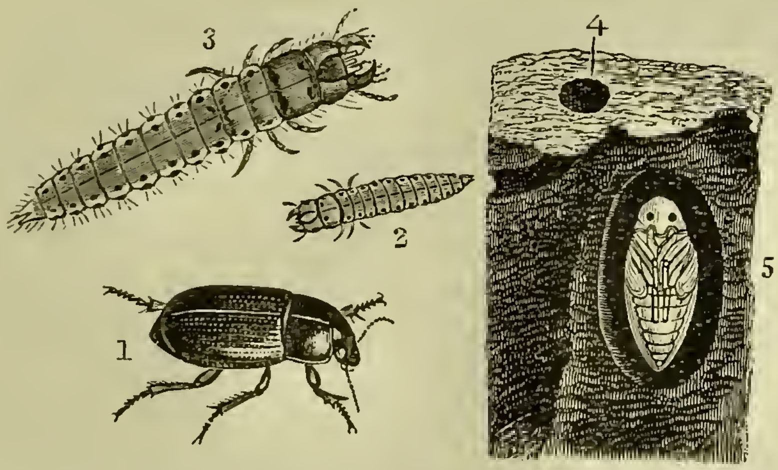

Fig. 84.—Corn Ground-beetle (*Zabrus gibbus*).

1, Adult; 2, 3, larva, nat. size, and magnified; 4, entrance to larval burrow; 5, pupa. (Curtis.)

Rove-beetles or Staphylinidæ.

These beetles can be told by the short truncate elytra, which eave the abdomen exposed. They somewhat resemble earwigs in appearance, frequently lifting up the hind end of their body. The larvæ are like those of the Ground-beetles, but have a relatively larger head. Some live upon dung and decomposing animal matter, others upon insects. The Devil's Coach-horse (*Ocypus olens*) may be taken as a type.

SHOT-BORER BEETLES (XYLEBORUS DISPAR AND X. SAXESENI).

These beetles belong to the family *Scolytidæ.* Both species attack and burrow into the wood of fruit-trees, forming long tunnels. The commoner species is *Xyleborus dispar.* They are short broad beetles, shiny black in colour, with pitchy red elytra, and covered with a yellowish pubescence: the females are from $\frac{1}{8}$ to $\frac{1}{6}$ of an inch long; the males, which are rare, about $\frac{1}{12}$ to $\frac{1}{10}$ of an inch. The beetles bore their way right into the wood of young trees as well as old ones, and in these tunnels the white larvæ are found in May and June, feeding upon some fungoid growth (Ambrosia) that lines the tunnels. The grubs pupate in the same place, and the beetles occur in September placed like a row of shot in the holes, and there they remain all the winter. *X. saxeseni* can be told from *X. dispar* by the thorax and elytra being more oblong in the male and narrower in the female. The males of both have their wings atrophied. Various other related forms of the genus *Scolytus* attack the bark of forest and fruit trees.

Prevention and Remedies.—All infested trees should be cut down and burnt in such attacks, so as to stop the pests from spreading. Remedies are practically useless.

HYMENOPTERA,

OR ANTS, BEES, WASPS, SAWFLIES, GALL-FLIES, ICHNEUMONS, ETC.

The Hymenoptera include the Ants, Bees, Wasps, Sawflies, Ichneumon Flies, Chalcid Flies, Sirices, and Gall-flies. Of these the Sawflies and the Sirices are very destructive; Ants and Wasps are sometimes noxious; whilst the Ichneumon-flies and Chalcid-flies are parasites, hundreds of species living upon other members of the insect world and so doing much good.

The Hymenoptera have both biting and sucking mouth-parts, a completely fused prothorax, and four membranous wings with few nervures and a dark stigma on the costa. Metamorphosis is complete. The head is provided with two large, compound eyes, and three ocelli on the vertex. The upper lip and mandibles are short, the mandibles being used for biting as in beetles. Maxillæ may be elongated, and long in those that suck up the nectar of flowers. The lower lip may form a long tube with the maxillæ, which is bent round in repose. In bees the tongue can be so elongated as to assume the form of a proboscis: in this case the lobes of the jaws become elongated, and form a sheath for the tongue. On the base of the fore-wings are found two scale-like bodies, the *tegulæ.* In Wood Wasps (*Uroceridæ*) and Sawflies (*Tenthredinidæ*) the pronotum is not united with the mesonotum. The wings are sometimes united together when expanded by a row of hooks. Wings may be absent (*Mutilla*), and in some of the workers, amongst the social Hymenoptera. The abdomen of the female may end in a sting, a saw, or ovipositor. The larvæ are of two types; generally they are apodal. The apodal forms pass their life as parasites in the body of other insects or in plants, producing "galls," or in cells in the nests of the social and gregarious Hymenoptera. The sawfly larvæ or "False-caterpillars" somewhat resemble those of the Lepidoptera, but there are six to eight pairs of abdominal legs, and they live free on leaves or in galls. The larvæ of the Wood Wasps (*Sirices*) live inside the wood of trees, and have only rudimentary legs. The grubs of social Hymenoptera are fed by the workers; they have a small, brown, retractile head,

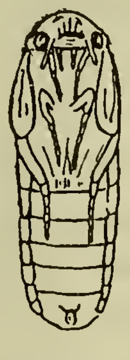

FIG. 85.—PUPA OF A SAWFLY.

with short mandibles and pointed maxillæ and labium. Some Aculeate Hymenoptera place in the larval cell, when the egg is laid, a half-paralysed insect, upon which the grub feeds when hatched. Many spin a silken cocoon, in which they pupate. Some undergo a curious stage which precedes the pupa, called the *pseudopupa.* The pupæ are usually pale and soft, with the legs of the future insect, &c., detached from the body (fig. 85).

The Hymenoptera are divided into two sub-orders—

(i) *Hymen. Petioliventres.* Including the Aculeata and Ichneumons. Abdomen connected to thorax by slender joint.

(ii) *Hymen. Sessiliventres.* Sawflies and Wood Wasps. Abdomen broad at the base.

Ants, Wasps, and Bees (Hymenoptera Petioliventres).

The Petiolate Hymenoptera include the *Formicidæ* or Ants, *Fossoria* or Digging-wasps, *Vespidæ* or true Wasps, and the *Apidæ* or Bees, and Ichneumon and other parasitic Hymenoptera. The Ants, Wasps, and Bees live in colonies, the *Fossoria* are solitary.

They are divided into three series—*Aculeata*, *Parasitica*, and *Tubulifera:* the first have a sting, and the second an ovipositor, the third have only three, four, or five visible abdominal segments.

The Aculeate Hymenoptera are classified as follows: *Heterogyna* or Ants, with the petiole of the abdomen having one or more scales, sexes consisting of ♂, ♀, ☿. *Fossores*, with simple petiole, ♂ and ♀ only. Wings not folded longitudinally. *Diploptera* or Wasps and Sand-wasps, with the wings folded longitudinally. *Anthophila*, hairs of body more or less plumose or branched.

ANTS (HETEROGYNA).

The *Formicidæ* or Ants are provided with strong mandibles for biting, the maxillæ and labium normal. All ants are social, living in colonies composed of workers, males, and females. The workers are always apterous; they are undeveloped females, and are often peculiarly modified for different purposes: some act as soldiers, others as labourers, and yet others as "nurses" for the brood. The males and females have wings. The abdomen, which is provided with a powerful poisonous sting, is united to the thorax by a one-jointed stalk in the genus *Formica*, by a two-jointed stalk in *Myrmica*. Those with the two-jointed abdominal-thoracic stalk are provided with a sting and are poisonous; but the genus *Formica* has no sting, yet is nevertheless poisonous. The latter bite, and then squirt the formic poison into the wound. During the greater part of the year a colony of ants consists only of workers, larvæ, and pupæ; but in summer winged males and females appear, which we see flying about on warm days. They pair in the air. When fertilised they fall to the ground; the wings are then torn off, and the female is borne along by the workers to deposit her eggs in the nest of the colony. Ant grubs are very feeble creatures: they are fed with specially prepared food by the workers, and when mature pupate in the same cells. The pupæ of the stingless ants (*Formica*) are in a cocoon; those of the stinging *Myrmica* are naked. These cocoons are usually called "ants' eggs," and form a valuable food for pheasants and other birds as well as goldfish. The dwellings of ants consist of passages and holes in wood and earth, and also of heaps of earth, pine-needles, and pieces of wood thrown up into hill-like areas. A large number of species are found in Britain, some more or less injurious. The food consists of both animal and vegetable substances. As destroyers of small caterpillars they are certainly beneficial, but they also do much damage. Some form their nests in meadows and cornfields, and render mowing a difficult operation. The nests they form, however, can be easily cut down, and the contents killed; whilst the earth spread over the grass will do much good. They may make pasture-land look unsightly, but they do as much good as harm. One peculiar habit is the curious way in which they keep colonies of Aphides, so as to draw the sweet honey-dew out of them; they even stimulate this secretion by stroking the backs of the plant-lice, and then take up the sweet drops as they issue from their cornicles.

One of our largest ants is the Red Wood Ant (*Formica rufa*), which forms dome-shaped nests in woods, especially pine-woods. Fruit, notably peaches, are seriously affected by these little pests.

Remedies for Ants.—Ants' nests are best destroyed by making a hole in the middle of the nest, pouring in about an ounce of bisulphide of carbon, and then closing up the hole with a piece of clay.

WASPS (VESPIDÆ).

The true Wasps are social insects like the Ants—males, females or queens, and workers being found in each colony. At the end of the year the colonies die off; only the fertilised queens live through the winter, hibernating in the thatch of houses, &c., during the cold months of the year. The queen appears in the spring and commences to make the nest. At first only a few cells are made, in each of which she deposits a single egg: from these workers alone are developed. The queen feeds the first brood of maggots, giving them small caterpillars, &c., chewed up into pulp. As soon as the first lot of workers are produced, the queen gives herself up entirely to egg-depositing, the workers doing all the duties of the nest. In autumn males and females come from the brood, the former fertilising the females, which hibernate during winter. The Wasps' nests are variable in form, some being ground nests (*Vespa vulgaris*), others swinging aërial nests (*Vespa sylvestris*),—they consist of a series of layers of cells, one deep. These layers or platforms are connected by vertical pillars one above another. The comb and cells are made of a papery substance; so also is the envelope enshrouding the layers of cells. This substance is made by the wasps chewing up decayed wood, the scrapings of the bark of trees, and the green slimy matter off water, mixed into a pulp with saliva: this dries into a greyish or tawny kind of paper. The opening is in the under side. The food consists chiefly of insects in the early part of the year, but later they attack fruit, and even rob bees of their sugary stores.

The commonest English Wasps are *Vespa vulgaris*, the Common Wasp; *Vespa sylvestris*, the Wood Wasp; *Vespa rufa*, the Tawny Wasp, common in sandy districts; and *Vespa crabro*, the hornet. Eight species are found altogether. The sting is in the form of a double-edged saw, with poison-bags at its base. Unlike the hive-bee, the wasp can sting any number of times.

Solitary Wasps are known as Sand Wasps or *Odyneri*; the fifteen British species are all more or less beneficial. They are smaller than those of the genus *Vespa*, and never live in colonies. They form burrows in sandy banks, with curved and tubular entrances, composed of pieces of mud. Like the wasps, they are all of some shade of yellow and black in colour. They provision their nests with small larvæ and weevils in a paralysed condition.

Remedies for Wasps.—The ground nests of *V. vulgaris*, *V. rufa*, &c., are best destroyed by burning sulphur in them of a night and blocking the nest up with clay; then digging them out next day, and burning the whole brood. Cyanide of potassium is often employed, but with no better results than sulphur, unless the nest is dug out afterwards in the same way. The hanging nests of *V. sylvestris* are more troublesome: by far the best plan is to shoot them down, late in the evening. Needless to say, all the spring queens should be killed whenever one can do so.

Bees (Anthophila).

The last division of the Aculeate Hymenoptera are the *Anthophila* or Bees, including the genera *Halictus*, *Andrena*, *Bombus*, and *Apis*. These have an elongated mouth, the maxillæ and lower lip forming the so-called "tongue" of the bee. The fore wings are never folded together longitudinally when at rest. Most are colonial in habits, and in some there is a distinct caste of workers, as in the hive-bee. The nests are made up of cells, and are very variable. The genus *Andrena* make their nests in sandy banks generally, some of wood, others of sand; and the *Apidæ* of wax. In the colonial forms only one queen inhabits each nest. Some cells are set aside for the brood, others for storing up pollen and honey. The genus *Nomada* or the Cuckoo-bees are non-colonial, and live as parasites in other bee-nests. The Andrenas have no worker form; for they also are non-colonial, but nevertheless gregarious.

Bombi, or Humble-bees, large, heavy, hairy species, are useful as fertilisers of plants: without their aid red clover cannot seed. In New Zealand red and other clovers were imported, and sown as a forage crop; but they never seeded until Bombi were also imported. The long tongue is the active agent in this cross-fertilisation.

The Honey-bee and its Relations.

Our Honey-bee is scientifically called *Apis mellifica*. It belongs to the last genus of Aculeate Hymenoptera, namely, Apis, the species of which are characterised by the absence of tibial spurs on the posterior legs, and by the presence of three cubical cells. All the members of this genus are permanently social. There are several well-known species of Apis, as well as a great number of local varieties of *A. mellifica*, which has been distributed over the earth by man. Our common honey-bee (*A. mellifica*) is a native of Europe, Africa, and Western Asia.

The German or Black bee and the Italian or Ligurian are the best known. The former is greyish-black in colour, and covered with tawny hairs. The queen and drones are darker, however, than the workers. The legs and ventral surface of the abdomen in the queen are brown, and of the drone greyish-brown. The *Ligurian* or Italian variety (fig. 86, A) comes from Northern Italy; it is also found in Naples. It is somewhat larger than the true *A. mellifica*, from which it can be told at once by the bright tawny yellow rings at the base of the abdomen, three in number in all pure-bred stock. The ventral surface of the abdomen is also golden yellow except towards the tip, which is black. The tongue is much longer than in the Black bee and more hairy. The Ligurian queen and drone vary, some being quite dark; but the workers always show, when pure, the three golden yellow bands on the abdomen. Besides these two there are numerous other races of *A. mellifica*, such as the *Carniolan*, said to be a very docile race; the *Himalayan*, a blackish-brown variety with tawny hairs at the base of the abdomen, but smaller than ours; and the *Maltese*, very similar to ours, but also smaller. Two well-known types are the *Syrian* and *Cyprian*. The former is banded with yellow and black, and much resembles the Ligurian, but has more yellow on the venter: this race is most prolific, and easily handled. The Cyprian may be told by the bright leather-coloured lunule which tips the thorax posteri-

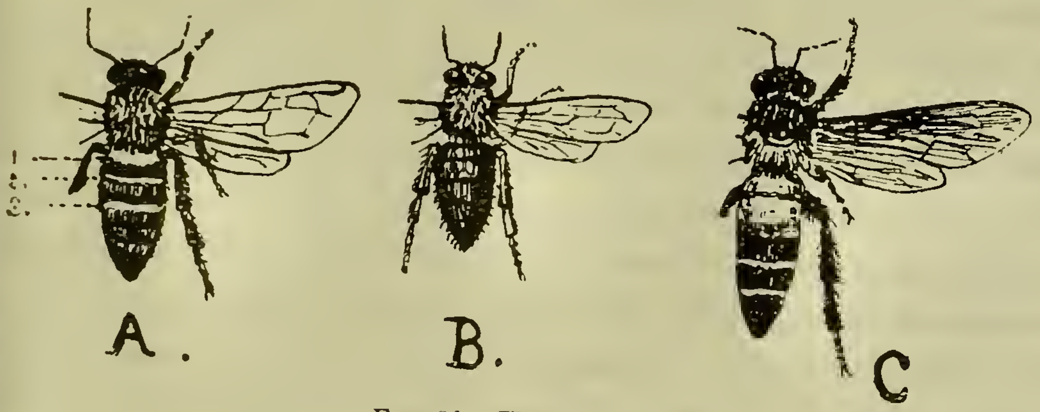

FIG. 86.—HONEY-BEES.

A, Apis mellifica *v.* Liguriæ; B, A. mellifica; C, A. dorsata.

orly, and the venter is yellow to the tip: like the Syrian, it is most prolific, but savage. The Egyptian bee (*A. fasciata*) is considered by some as a distinct species, but is probably only a variety of *A. mellifica:* it is considerably smaller than the Italian. The pretty little Indian Bee (*A. indica*) was also at one time considered distinct from our hive-bee; but although very different in appearance, it is only a variety. It is extensively cultivated in India, and has tremendous hives, containing as many as 80,000 individuals: it is a small bee, with much golden yellow on the body. Various other races exist.

The Giant Honey-bee of India (*A. dorsata*) (fig. 86, c) is much larger than any of the varieties of *A. mellifica*, the worker being quite as large as a Ligurian queen. The wings of *A. dorsata* are dusky black; the base of the abdomen is dull orange-yellow, and two pale yellow bands run across the remainder of the blackish-brown abdomen; while the dark thorax is clothed with tawny hairs posteriorly. The drones are said to be dark-brown marked with yellow (these I have not seen); and the queen is leather-coloured. The comb of *A. dorsata* is often six feet long and four feet wide; it hangs from branches of trees, ledges of rock, and in crevices of rocks. The comb is similar to that of our honey-bee, but the layers are placed closer together. It is extremely abundant in the jungles of India. A distinct variety, *A. zonata*, with large broad abdomen, dusky black except at the base, and with a thick tawny pubescence on the thorax, is also recorded from India and the East Indies. *Apis floræ* (Fab.) is quite distinct; it is a small delicate bee, with much tawny yellow at the base of the abdomen, the tip being dusky brown with two pale bands in the middle. Mr Sladen sent me a beautiful variety, *andreniformis* (Smith), which is deep brownish-black, with two pale silvery bands in the middle of the abdomen. The stings of *A. floræ* and *A. indica* are very small.

In Mauritius and at Réunion is a doubtful species, *A. unicolor*, which produces green honey. There are several others with doubtful specific characters, with which we cannot deal here, enough having been said in relation to the species of *Apidæ.*

All the members of the genus dealt with above live in permanent colonies. There are three individual forms—the perfect female or queen, the imperfect female or worker (wrongly called a neuter), and the male or drone. The queen's sole function is to lay eggs; her ovaries are very large, and nearly fill the abdomen. The female is longer than either drone or worker; her mouth organs are not so fully formed as in the worker: the tongue, labial palps, and maxillæ are much shorter, and the curious pollen-baskets on the hind-legs are absent. The queen sting is curved like that of a Humble bee, and has fewer barbs than that of the worker. The drones or male bees are found in the summer. The presence or absence of drones depends on the condition of the colony. The drone of *A. mellifica* is much shorter than the queen, and more robust. When flying, the drone produces a loud buzzing noise. The eyes meet above (holoptic), whereas in the queen and worker they are separate. No sting is developed, nor pollen-basket. Drones hatch from unfecundated eggs, but queens and workers from fecundated ones. Workers often lay eggs, which invariably turn to drones (parthenogenesis). The workers are abortive females, and vary from 15,000 to 45,000 in each colony; whilst *A. indica*, as mentioned before, may number 80,000 in one colony, when fully stocked. The maxillæ (fig. 87, *mx*) and labium are much elongated, the latter deeply grooved and joined to the head by two rods (*cardinales*), *ca.* The sides of the maxillæ (laciniæ) (*lac*) are stiff, and form a tube connected with the oral orifice; the labium is long, and united to the maxillæ by the submentum and two rods. From the mentum proceeds the lingua or tongue (*li*), labial palps (*lp*), and paraglossæ. The tongue is hairy, and consists of a ringed sheath, slit beneath. Within the tongue is a rod which extends beyond its tip, also cleft ventrally. When not in use, these mouth-parts are bent under the head. The jaws or mandibles (*m*) are strong, and are used for cutting comb and kneading up the wax. Another structure of interest in the worker is the "pollen-basket" on the hind-legs, in which the pollen is amalgamated, then collected by the bee's mouth, and transferred to the four anterior legs, to be taken to the hive. This structure is a deep cavity on the outside of the posterior tibia and first tarsal joint, with a rim of hairs. Workers all possess a sting, which is straight. The poison ejected with the sting is an acid fluid secreted by two coiled glands (*P.g*), and is stored up in a small sac (*P.s*). This

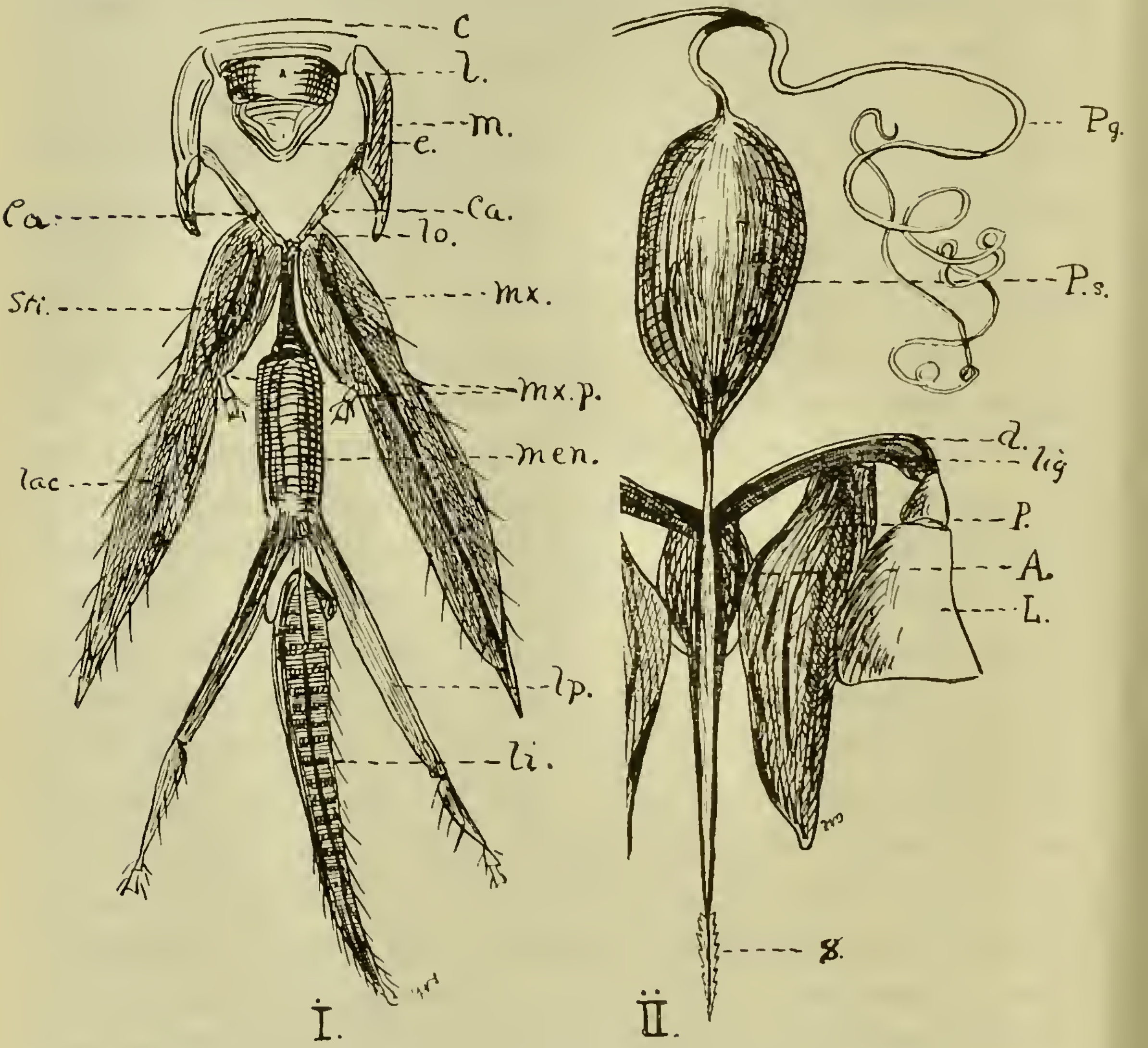

FIG. 87.—(i) MOUTH AND (ii) STING OF BEE, DISSECTED.

c, Clypeus; *l*, labrum; *e*, epipharynx; *m*, mandibles; *Ca*, cardinales; *lo*, loræ; *mx*, maxillæ; *Sti*, stipes; *lac*, lacinia; *mx.p*, maxillary palps; *men.* mentum; *li*, lingua; *lp*, labial palps; *P.g*, poison gland; *P.s*, poison sac; *s*, lancet; *A*, base of stylets; *d*, curved root of sting; *lig*, angular piece; *L*, end of lever.

poison-bag is connected with the sting by a tube. The piercing organ consists of three needle-like points: one is larger than the others, and this large style (*s*) has a reservoir at its base where poison is stored up. The two smaller lancets are hollow, and are barbed with eight to ten barbs, which hold and cause the sting to be pulled out when the bee tries to withdraw it. In the act of stinging the awl first pierces, then the lancets.

The ova that give rise to workers hatch in three days into white footless grubs, which are fed by workers, and mature in eight days. The food of the grubs that are to become workers consists of a scanty supply of a white fluid composed of pollen and honey. The cell in which the grub lives is then capped over with pollen and wax. The larva, when mature, spins itself a cocoon of white silk of extreme thinness. Three days after the insect has been capped in, it pupates. In another week the bee emerges. The freshly emerged bees do not leave the nest for two days or so, and are easily told by their paler colour. As a rule, a worker lives from eight to ten months, when hatched in the autumn, but when hatched in the spring it seldom survives more than three months. Worker-bees do all the work of the hive, secrete wax, build the comb, feed the brood, and ventilate the hive. The older bees chiefly collect the honey, pollen, and the so-called propolis. The hives are ventilated and the temperature reduced by the violent vibration of the bees' wings, whilst extra heat is generated by forced respiration.

The queen-bee comes from an egg placed in a specially prepared cell, usually situated on the edge of the comb, and composed of wax and pollen. A queen-bee may be formed from an egg or from a worker larva when quite young, the larva being surrounded by a "queen cell." The larva destined to become a queen is fed on a plenteous, rich, nitrogenous diet, "queen jelly," with which the cell is completely filled. The queen larva is longer and larger than the worker, and feeds for five days, then forming her open cocoon, in which after three days she pupates, and at the end of sixteen or seventeen days emerges as the "queen." A few days later the queen flies out of the hive, and whilst on the wing is impregnated by the drone. She then returns to the hive to commence egg-laying. As many as 3000 eggs are laid per day: these will turn into workers or queens; but should the queen not be pregnant, the ova turn into drones only, and similarly at the end of queen life. The female *A. mellifica*, unlike the worker, may live for three years: some queens have been said to retain their vitality for as long as five years.

The drone grubs feed for six or seven days, and then are "capped" in their cells, the covering being very convex, a feature by which we can always tell drone cells; the wax is impure, and thus the cell is darker than the others. In twenty-five days the drone emerges. These males are killed off by the workers, and even the drone brood is destroyed by them when they are not required. Their sole function is to impregnate the queen, which act entails their death, the copulatory organs being left in her vulva.

Swarming takes place when a hive or colony becomes overstocked or disturbed by mice and other causes. This swarming is most erratic. The bees cling together upon some tree or fence, and then, accompanied by the queen, fly off to their new home, apparently previously sought out, for they are said to fly direct to their new abode, and there soon commence a fresh colony. The three substances formed by bees are *honey*, *wax*, and *propolis*. The first is made from the nectar of flowers. The nectar is taken into the crop or honey-stomach and altered into honey, which the bee regurgitates into the already formed honey-cell, this cell being eventually capped. Honey is stored for the use of the mature bees, and, when mixed with pollen, to form food for the brood. Wax is formed as a secretion in scale-like plates beneath the bee's abdomen in four pairs of so-called "wax-sacs," and is seemingly formed from nitrogenous food. When ripe, the wax-scales are removed by the bee's claws, and taken by the mouth and mixed with saliva to form a plastic substance from which the cells are moulded. Propolis is the product of resinous substances off buds of trees, &c., collected by the bees to use as cement, and to fill in crevices between the irregular cells in the comb, and for the attachment of the latter.

The other group of this division, the *Fossores,* are the Digging-wasps. *Cerceris arenaria* and *Pompilius plumbeus* are two common types. The former is black and yellow, the latter red and black. They are lively solitary insects which hunt for their prey. The females often dig a hole in the ground in which to lay an egg; in this is also placed a grub, to serve as food for the newly hatched larva. The buried grub is not dead, but paralysed by the sting of the Digging-wasp (*Pompilius*). All being insectivorous, we may look upon them as beneficial to us.

Ichneumons, Gall-flies, &c. (Hymenoptera parasitica or terebrantia).

The chief families are—

(i) The *Chalcididæ,* whose larvæ are parasitic in various insect larvæ and ova, and even in other parasites;
(ii) The *Braconidæ,* which attack caterpillars and beetle-larvæ;
(iii) The *Ichneumonidæ,* which attack all larvæ;
(iv) *Proctotrupidæ*—Larvæ parasitic in eggs and bodies of other Arthropods; and
(v) *Cynipidæ*—Parasitic in plants, &c.

The ova laid by the various insectivorous insects hatch into little grubs, which gradually devour their host, but not until they and their host have nearly reached maturity, when they pupate either within or external to their prey. Some, however, oviposit in insect eggs. The little yellow cocoons we often see in abundance around the larvæ of the Large Cabbage-white (*Pieris brassicæ*) in the autumn are the cocoons of one of the Braconidæ, *Microgaster glomeratus*, which aids so much in destroying these noxious larvæ on our cabbages. *Vide* also fig. 95, 5.

These insects vary much in size: some are microscopic, while others are quite large. All, however, are equally beneficial, and worthy of our protection.

The Hessian-fly is largely parasitised by these insects; so are Aphides. We can nearly always find some dead plant-lice on every tree—pearly looking bodies, often with a minute round hole, showing where the parasite has escaped.

GALL-WASPS OR CYNIPIDÆ.

Gall-wasps produce a great variety of deformities upon trees and plants. There are many interesting features in these insects, and their life-histories are often very complex. They are mostly small, with apodal grub-like larvæ (fig. 88, D). They are subject to great numbers of parasites, and have other harmless guests (inquilines) called Synergi living in their galls. The thorax is humped and the abdomen short. The females, which have the ovipositor curved upwards from the ventral surface, deposit their eggs in plants and trees. The eggs are sometimes placed on long stalks or peduncles, usually in groups or clusters (B), but sometimes singly. Those here figured are of *Biorhiza terminalis* laid in the terminal buds of the oak. The larvæ, which are curved, white, footless grubs, pupate in the galls, some developing in a few days (catkin galls), others taking a long time to mature (woody galls). The "galls" were at one time said to be formed by an irritating venom ejected into the wound. This is not the case. The galls are produced by the irritation set up by the larvæ. We find, as a rule, two forms, a sexual form and an agamic form. The galls of each differ. Those whose galls appear in the autumn are always asexual. We thus get an alternation of an asexual autumn generation and a sexual spring generation. Parthenogenetic reproduction then takes place in these Cynipidæ. Some are parasitic on Diptera and others on Aphides. Oak apples are formed by *Cynips kollari* (A) and *Biorhiza terminalis.* The Bedeguar or mossy galls on the rose are formed by *Rhodites rosæ.*[1] The majority of Cynipidæ are found on the oak, a few on the rose and other plants. The ink galls of commerce are formed by Cynipidæ. Tits, especially the Blue and Great Tits, peck the grubs out of these galls in great numbers. (Fig. 88, A, *b*.)

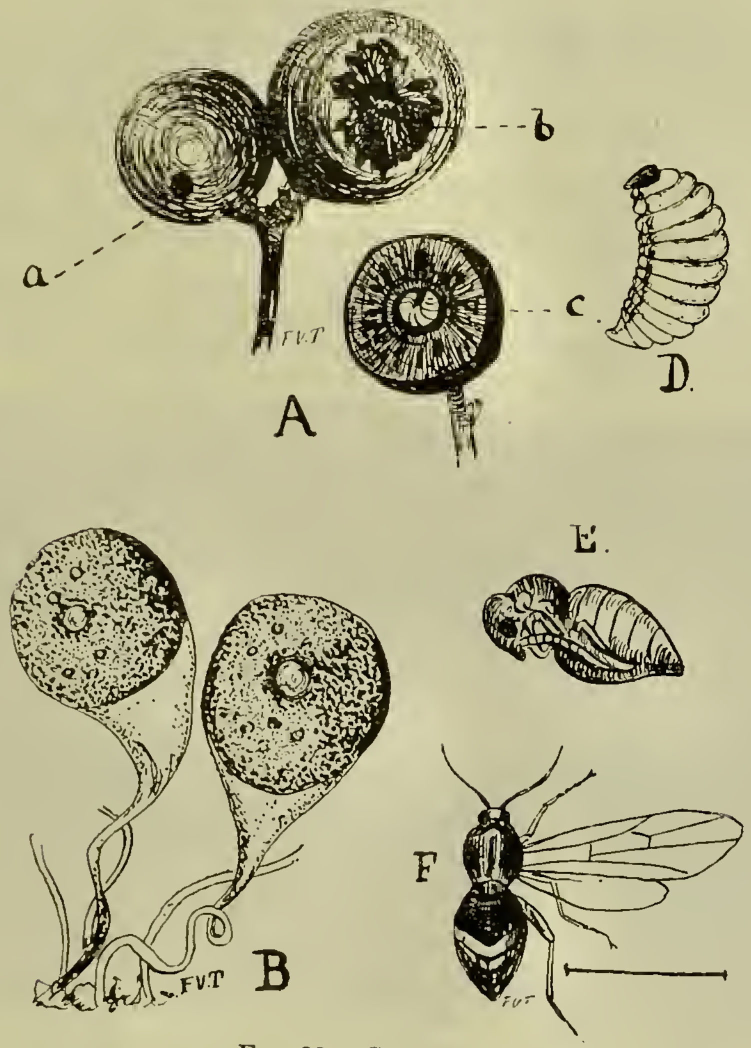

Fig. 88.—Cynipidæ.

A, Galls of *Cynips kollari*: *c*, maggot; *a*, hole of escape of fly; *b*, gall attacked by tits. D, Larva. E, Pupa. F, Imago. B, Ova of *Biorhiza terminalis*. (The ova are from preparations sent me by Mr Hammond.)

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[1] According to the late Mr Ashmead, the farmers at Harrogate gather these galls to make an infusion for the cure of diarrhœa in cows (Müller, Zool. S. S., p. 1206).

The Sawflies and Wood-wasps (Hymenoptera sessiliventres).

Sawflies and Wood-wasps are phytophagous, with sessile abdomen, the larvæ resembling caterpillars in the former group.

(1) The Sawflies or *Tenthredinidæ* have a sessile abdomen, with short saw-like borer (fig. 89) of a complex structure, which is only exerted during egg-laying. The mandibles are well formed, but the rest of the mouth is weak. The sawflies lay their eggs by cutting a slit in the epidermis of the leaf; in this a single ovum is deposited, and the slit may be closed by a gummy excretion. The larvæ are called "False-caterpillars," and feed voraciously on leaves and even fruit. Some form galls on willows, &c. They have twenty-two or more legs, and can thus be told from the Lepidopterous larva. Often when young the larvæ are gregarious, but separate as they grow older. They all, or nearly all, spin cocoons, which may generally be found in the ground beneath where the larvæ have been feeding. The cocoons are often covered externally with small particles of earth. They remain in this position all the winter

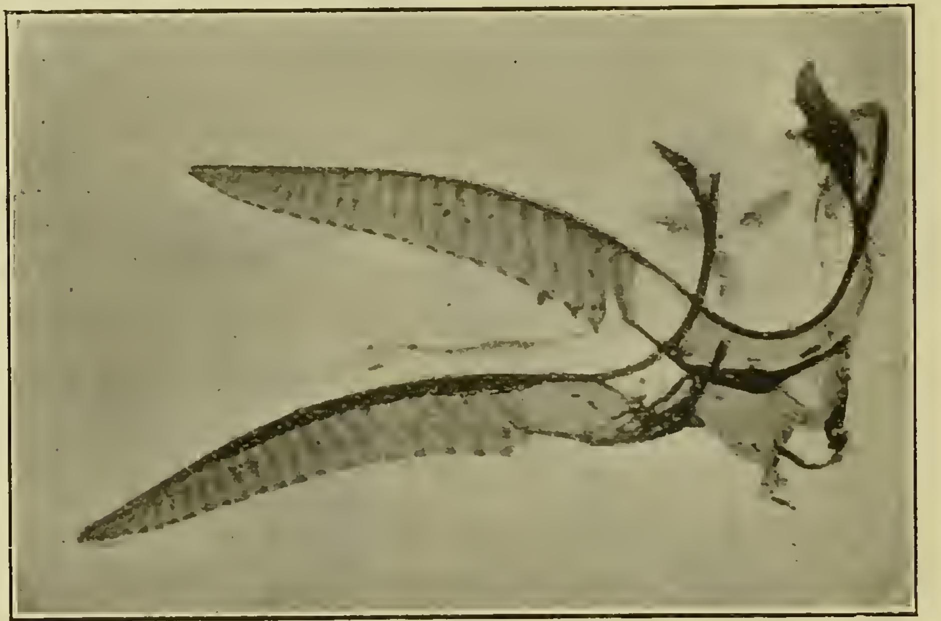

Fig. 89.—Saw of a Female Sawfly (greatly enlarged).

—some as larvæ, which pupate in the spring, others as pupæ. There may be two or more broods in the year. Some species, such as the Slug-worm (*Eriocampa limacina*), are cosmopolitan, doubtless having been distributed in the pupal stage in the earth at the roots of nursery stock. The following are three typical injurious species:—

The Currant and Gooseberry Sawfly (*Nematus ribesii*).

Fruit-growers are constantly troubled with the "false-caterpillars" of this species on their gooseberry-bushes, and sometimes on the currants. The larvæ can be told by the number of sucker-feet and the curious positions they assume, often with the tail turned up over their back. They are bluish-green in colour, spotted with black, and marked at the sides with turquoise-blue and yellow; the first segment and the last but one are yellow. When full grown they reach half an inch in length, and become pale green, except behind the head and near the tail, which retains the yellow colour. The Sawfly appears in April, and may be seen settling on the gooseberry leaves. It has four slightly iridescent wings, an orange abdomen, and black and yellow thorax: they vary from half an inch to rather more than an inch across the wings. The female, which is larger than the male, cuts a number of little slits in the leaf, along the edge, and in each she deposits a single ovum. The eggs hatch out in about a week, sooner if the weather is favourable; the young larvæ feed close together for some time. We can tell their presence in this early stage

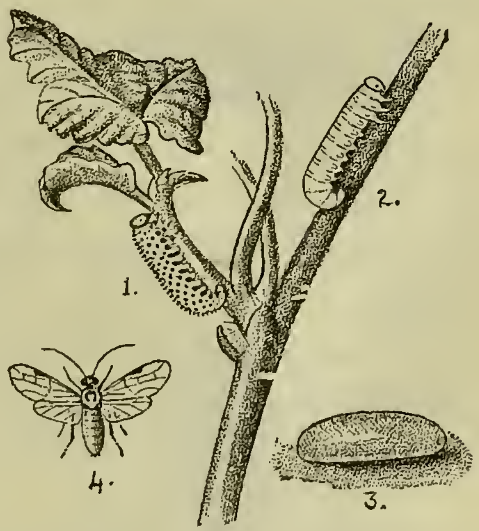

Fig. 90.—Gooseberry Sawfly (*Nematus ribesii*).

1 and 2, Larva in two last stages; 3, pupa; 4, imago. (Whitehead.)

by noticing the leaves here and there being riddled with small round shot-holes, in each of which is a young sawfly larva. As they grow they disperse over the bush, reaching maturity in from four to five weeks. When full grown they are three-quarters of an inch long. They then leave the bushes and burrow an inch or two under the soil beneath, where they pupate; some even pupate on the shoots. Very often these pupæ hatch out from two to three weeks later, giving rise to a second brood: this second brood often attacks the fruit as well as the leaves. A third brood also may occur. When mature, like the first generation, they bury themselves in the ground, and remain there all the winter.

Prevention and Remedies.—The removal of the soil to the depth of a couple of inches in winter and burning it, replacing in spring, will have the desired effect of checking their increase where it can be done, as in gardens.

Where gardens are subject to this attack, much loss of time and money would be saved by a thorough examination, by boys, of the bushes in the late spring, so as to collect and destroy the young larvæ before they have spread over the whole bush. White hellebore is the most certain insecticide to use, mixed as recorded hereafter; but the best remedy is spraying with tobacco wash or arsenate of lead. Even soft-soap and quassia kill them.

The Pear and Cherry Sawfly (Eriocampa limacina).

Considerable annoyance is often caused by the larvæ of this species upon Cherry and Pear. The larvæ (fig. 91) are called Slug-worms and Snegs, on account of their slimy slug-like appearance. They feed on the upper surface of the leaves, eating only the upper epidermis, and leaving the lower intact (fig. 93). When very numerous the leaves turn brown, die, and fall off in the summer, and a fresh lot of foliage takes its place, thus weakening the trees. The adult Sawfly (fig. 92) is a small glossy black insect, about one-fourth of an inch in length; the wings are iridescent, with the middle area smoky black, and are about three-quarters of an inch from tip to tip. The parent fly comes out of the ground beneath the trees in the spring, generally in May. In most cases a single egg only is placed on the under-side of each leaf, its position being easily told by the small pale spot that appears over it. The ovum hatches in two weeks, and the larva escapes to the top of the leaf. At first it is pale and free from slime; but soon a slimy exudate comes out of its skin and gives it its typical slug-like appearance. Its form is peculiar, being much swollen up at the head-end: it has twenty legs. In four weeks the slug-worm has reached maturity, when it attains the length of half an inch. At the last moult (the fifth) it loses its slimy character, and becomes dry and dirty-yellow in colour. It then falls to the ground, where it forms a cell and pupates. In the summer broods, of which there are three in England, the pupal life lasts about fourteen days. It seems

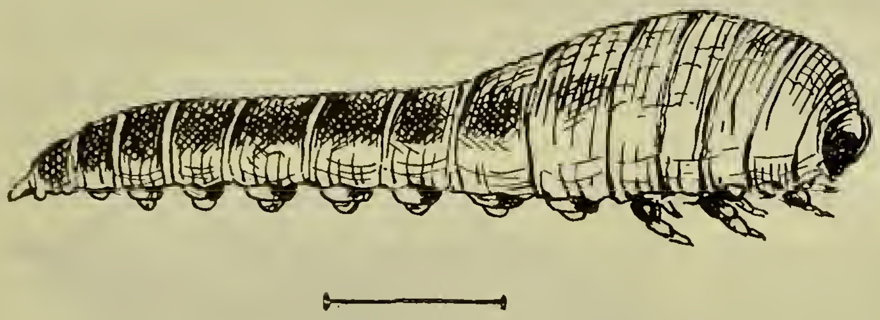

FIG. 91.—SLUG-WORM OF PEAR (*Eriocampa limacina*).

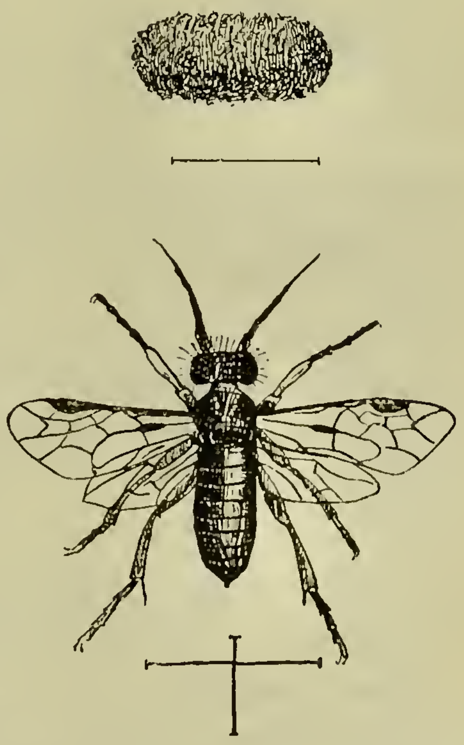

FIG. 92.—PEAR SAWFLY (*Eriocampa limacina*), and cocoon.

that they do not all undergo these stages at the same time, some remaining in the ground much longer than others. Numbers of larvæ are often found on one leaf of different sizes, the eggs having been deposited at various times.

Prevention and Remedies. — Similar preventives apply here as in the Gooseberry Sawfly. Lime will soon kill the larvæ if it is applied twice in succession, as they have the power, like slugs, of passing out a coat of slime and leaving it and the lime behind. They are best destroyed by the arsenical washes mentioned in Appendix II. Arsenate of lead was found very successful in 1897 at the S. E. Agricultural College Fruit-Gardens.

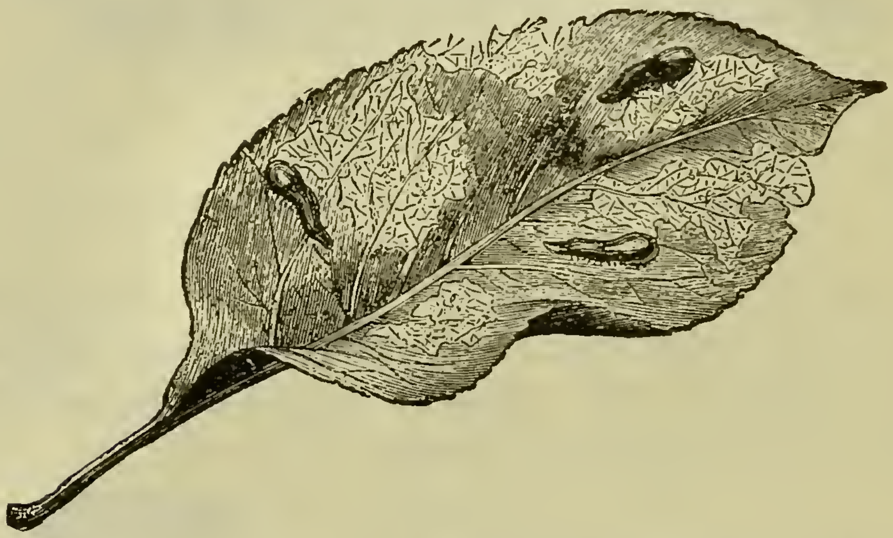

FIG. 93.—SLUGWORMS (Larvæ of *Eriocampa limacina*) upon a leaf.

The Corn Sawfly (*Cephus pygmæus*).

The Corn Sawfly belongs to a different section (*Cephinæ*) to either of those already mentioned. The body of this corn pest is flattened from side to side, keel-shaped. It has long been known as a corn pest, but it is never very serious in this country, as it is sometimes on the Continent. All kinds of straw crops are attacked, but *C. pygmæus* seems to show a decided preference for wheat. The adults appear in June and

July; they have a black-and-yellow-banded body, brighter in the male than in the female; the former sex is rather more than one-third of an inch long, the latter slightly smaller; wing expanse just over half an inch. The female cuts, by means of her saw-like ovipositor, a slit just beneath the developing ear of corn, and there places a single egg, closing the hole up as others do in this group. In two weeks, or a little less, there comes from the ovum a small white larva, which at once commences to devour the inner parts of the straw: as the larva grows it works downwards, until about harvest-time it has reached the bottom of the straw, having eaten its way through the successive nodes. When mature it reaches half an inch in length; it is white, and, unlike other Sawfly larvæ, it is nearly apodal: a few small lumps below are all that remain of the typical sucker-feet. When the bottom of the straw is reached the larva turns round, and then cuts the straw off an inch or two above the ground as clean as if cut with a sharp penknife. The winter is passed in the stubble, where the larva spins a cocoon of pale loose silk, pupating in the cocoon in the very early spring. Some live in wild grasses at the headlands, hedges, and woods, so that we have constant fresh infestations coming.

Prevention.—If the stubble is simply ploughed in after an attack of corn sawfly, unless very deeply, a large number of the insects will hatch out and escape from the ground. It is advisable where this pest has been very bad to scarify the fields and harrow the stubble together and burn it: by so doing all the larvæ in the "gratten" are destroyed, and thus subsequent harm prevented.

Many other Sawflies are often injurious, including the Apple-Sawfly (*Hoplocampa testudinea*), which eats the young apples, and the Pine Sawfly (*Lophyrus pini*), which is sometimes most injurious in pine-forests, and the Large Larch Sawfly (*Nematus erichsoni*).

Wood Wasps (*Siricidæ* or *Uroceridæ*).

The second group are the Wood Wasps or *Siricidæ*. The Sirex-flies have a long freely projecting ovipositor, by means of which the female places her ova in the wood of coniferous trees. Two species are destructive to conifers in England, namely, the Giant Sirex (*Sirex gigas*) and the Steel Blue (*S. juvencus*). Both are large insects, the former species often being an inch and a quarter long in the female, with four tawny wings and black and yellow body; *S. juvencus* is somewhat smaller, and beautiful steel-blue in colour. The ova laid under the bark of the trees hatch into white, nearly footless, larvæ, which eat their way into the very heart of the wood, forming long tunnels which are partly blocked up as they progress with their "frass." They seem to live in this position some nine months, and pupate somewhere near the bark, so that in the summer when the Sirex is mature it can easily eat its way to the open. The adults have extremely hard and strong biting mouths, and leave behind a large round hole in the trunk that we very often notice on pine-trees. Numbers of larvæ usually inhabit each tree, so that it is soon killed. It is always advisable to cut down and burn any tree showing symptoms of their attack in the winter when the borers are at home.

LEPIDOPTERA,

or Butterflies and Moths.

The Lepidoptera or scaly-winged insects are the Butterflies and Moths. The former are known as Diurni or *Rhopalocera*, and have always club-shaped antennæ (fig. 95, 1), and the wings are always held vertically over the back when in repose. They are day-fliers. The moths or *Heterocera* have either thread-shaped, feathery, or pectinate antennæ; the wings are usually folded over the back in repose.

Lepidoptera are haustellate, the mouth being prolonged into a long sucking proboscis or antlia. The scales are the colouring part of the wing: they easily rub off, when the membranes of the wing are seen to be transparent.

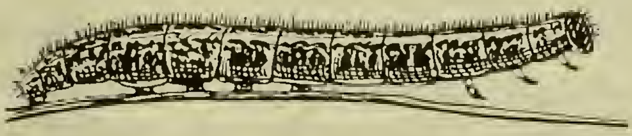

FIG. 94.—LARVA OF THE LARGE WHITE (*Pieris brassicæ*).

All Lepidoptera have a complete metamorphosis. The ova are often beautifully sculptured. The larvæ or caterpillars have six true legs and usually four pairs of prolegs, with the addition of an anal pair at the hind end. The larvæ are mostly vegetarians, and are provided with strong biting mandibles. They moult four times. The length of life is very variable: some only live ten days, others two or three years (Goat Moth—*Cossus*). The pupæ may be naked, girdled by a band of silk, or enclosed in a cocoon of silk or a cell of earth. The adults are nearly always winged, except in some female moths (Winter Moths), and are usually short-lived. Some imagines hibernate (Tortoiseshell Butterfly), and these have a longer period of existence. Large numbers of moth larvæ are injurious, but only a few Rhopalocera.

BUTTERFLIES (RHOPALOCERA) (Fig. 95).

Amongst the seventy British Butterflies only three (*Pieridæ* or Whites) can be considered of any economic importance, although others, such as the Comma (*Vanessa C.—album*) and the Peacock (*V. io*), may attack hops, and the Large Tortoiseshell (*V. polychlorus*), cherries. The clubbed antennæ always identify a butterfly. The larvæ, too, are often spiny (*Vanessidæ*). The pupa or chrysalis (4) is angulated, and generally pale in colour. No cocoon is formed, the chrysalids either hanging with the head downwards and attached by a lump of silk at the tail, or suspended head upwards, when they are girdled *lepidoptera.* The last three contain the majority of the injurious species.

The *Sphingina* are the Hawk-moths (*Sphingidæ*). They are provided with a long proboscis and usually pointed abdomen. The antennæ taper to a point at the end. The larvæ of the Hawks have a curious horn on the last segment, and live upon the leaves of various plants. The Eyed-hawk (*Smerinthus ocellatus*) may be taken as an example, and is sometimes harmful to apples.

The larvæ of the Clearwings (*Ægeriidæ*) are all creamy-white in colour, and live by burrowing into the stems of shrubs and trees.

The Currant Clearwing (Ægeria tipuliformis).

This pretty little moth (fig. 96) is often very injurious in black-currant plantations. The Clearwings (*Ægeriidæ*) take their name from the fact that the major area of their wings is transparent. This species is a little more than two-thirds of an inch in expanse of wing; the body and thorax are purplish black with yellow bands. These clearwings have a black fringe to the wings, a black bar across the fore-wings, and the ends with black veins and with a yellowish sheen. The currant clearwing appears in the latter part of May, but chiefly in June. The female lays her eggs where a small twig breaks off, and also on the buds, the larvæ making their way into the centre of the shoots. The caterpillars, which are creamy-white, tunnel both up and down the stems during the winter, and by April are full-grown (three-quarters to nearly an inch long). They then pupate in a cocoon of loose silk in the tunnel. The brown spiny pupa pushes its way out of a hole (fig. 98, *a*) previously formed by the larva up to the rind of the stem, when the moth bursts its way out. All kinds

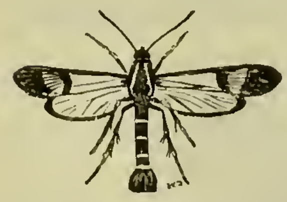

FIG. 96.—CURRANT CLEARWING (*Ægeria tipuliformis*).

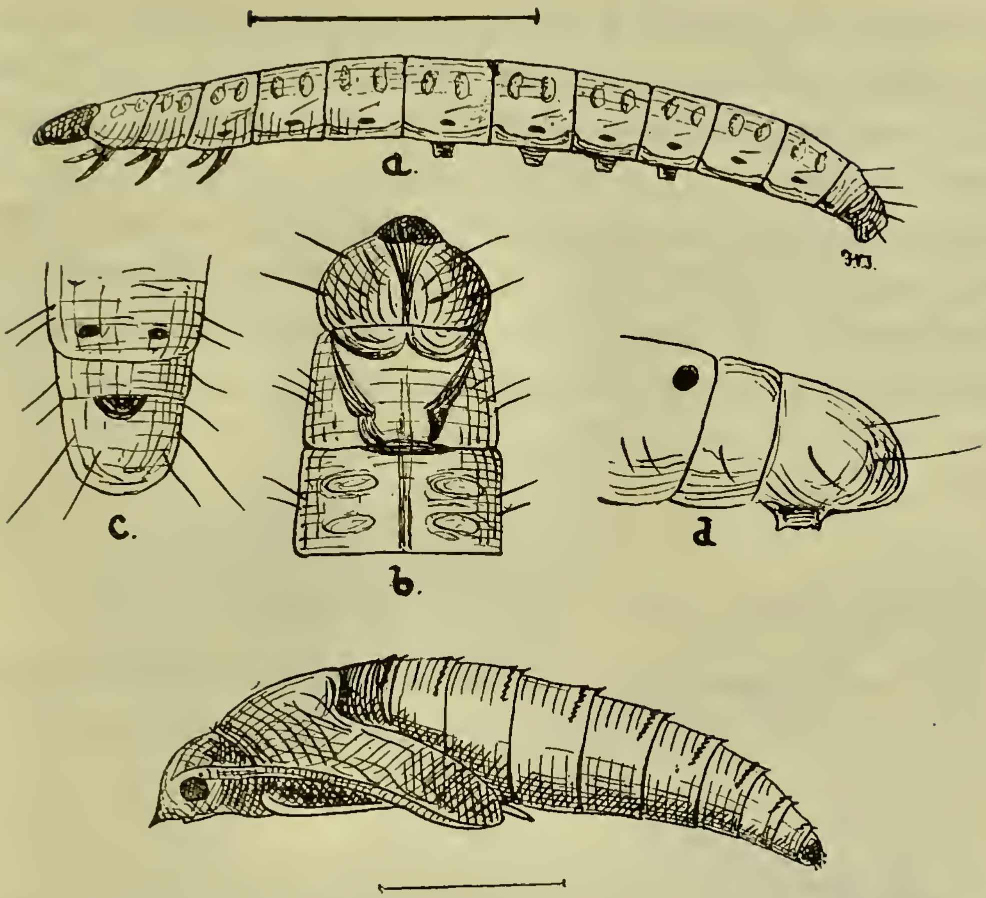

FIG. 97.—LARVA AND PUPA OF CURRANT CLEARWING (*Ægeria tupuliformis*).
b, Enlarged head; *c* and *d*, anal extremity of larva.

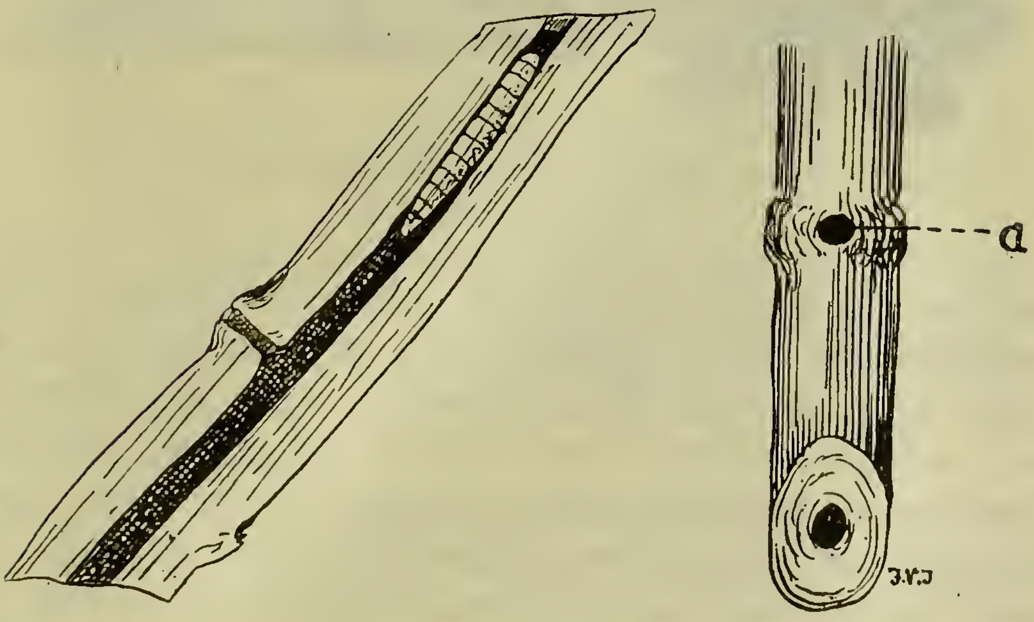

FIG. 98.—BLACK CURRANT STEMS DAMAGED BY LARVÆ OF CURRANT CLEARWING.

of currants are attacked, but especially the black varieties. The moths appear on the wing chiefly during the early hours of the morning, when they may be seen hovering over the currant-bushes.

Remedies.—One can easily detect a hole in the bud, which is about the eighth to the sixth of an inch across, where the larva has entered. By pruning the infested shoots back until no signs of a tunnel are left, and by burning the prunings, this somewhat local pest would soon be cleared out of an infested garden or plantation.

The Garden Swift-moth (*Hepialus lupulinus*), &c.

The family **Hepialidæ** or Swift-moths includes two injurious species—namely, the Garden Swift (*H. lupulinus*) (fig. 99) and the Ghost-moth (*H. humuli*) (fig. 100). The former is very destructive in its larval stage to garden produce, and the latter to grass and hops. The larvæ of the Hepialidæ live underground upon the roots of plants, but sometimes they burrow into the root itself and up into the crown of the plant. They are dirty-white in colour, and have large brown heads and scattered bristle-like hairs over the body. The garden swift-moth lays her eggs during the

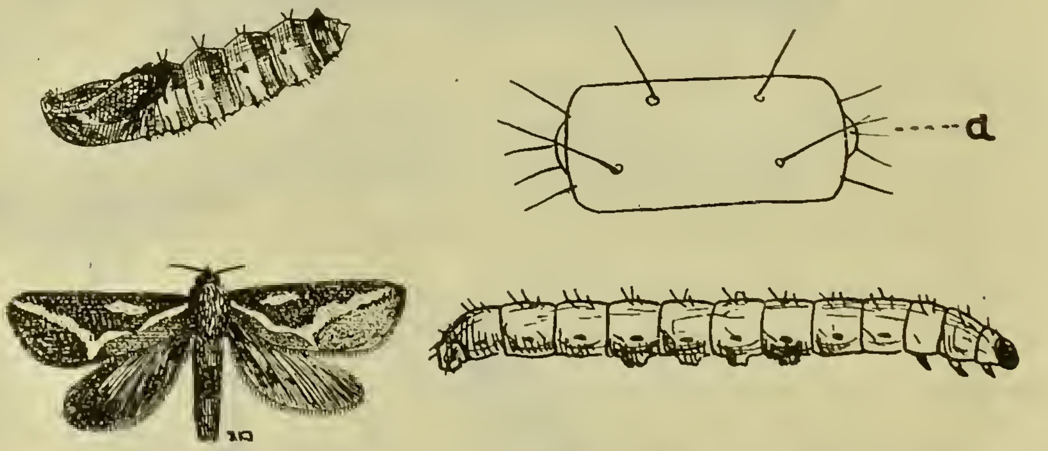

Fig. 99.—Garden Swift-moth (*Hepialus lupulinus*), pupa and larva. *a*, Enlarged segment of larva.

latter part of May and in June, whilst in flight, amongst vegetation. The larvæ feed upon the rootage just beneath the soil, and continue all the winter. In the spring they pupate in the same place : the pupæ are chestnut brown, with circles of spines around them. The larvæ are often quite green, although the skin is white, the food showing through. They are very active underground, preferring loose soil to work in ; when put on the soil or in the hand they wriggle violently backwards when touched. Strawberries, lettuce, and mint seem their favourite diet. The moth is about an inch in expanse of wing and brown in colour, with white markings as shown in fig. 99, and flies with great rapidity at dusk over the tops of the grass and other plants.

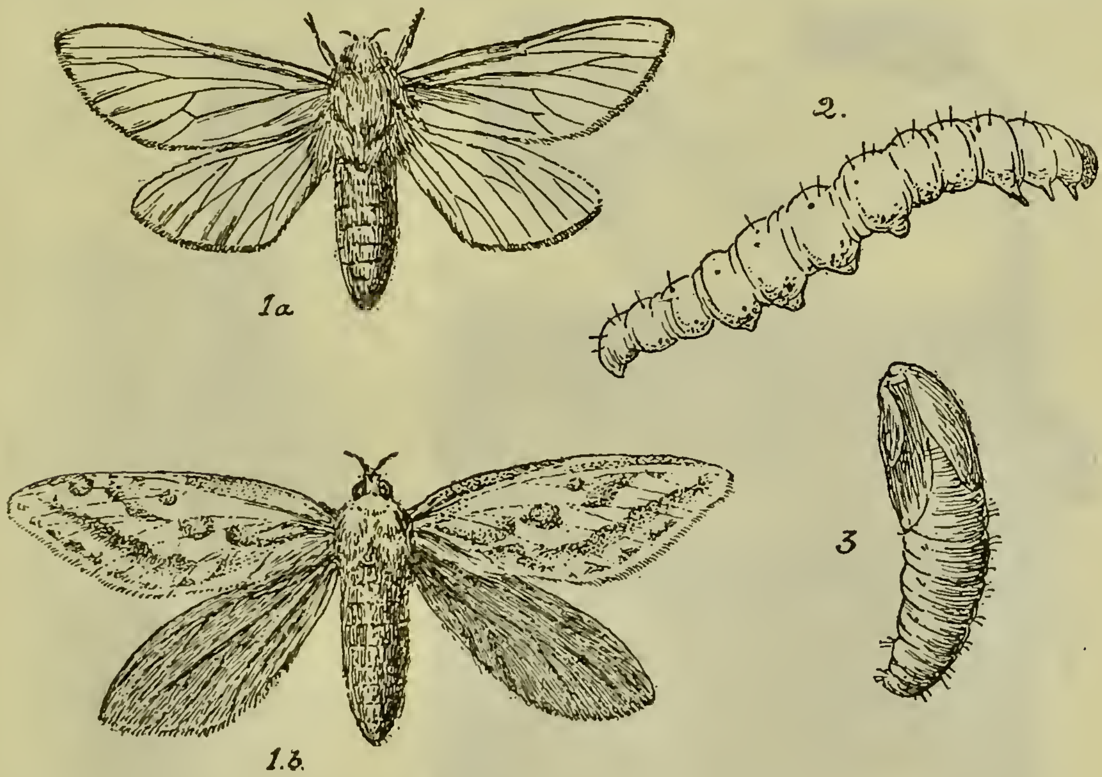

Fig. 100.—The Ghost-moth (*Hepialus humuli*).
1*a*, Male ; 1*b*, female ; 2, larva ; 3, pupa.

Remedies.—Dry dressings of soot, lime, kainit, or vaporite in the winter drive them away or kill them, whilst prong-hoeing disturbs them and exposes some to the attack of birds.

The Ghost-moth (*H. humuli*) is a large, pure, satiny-white moth, in the male sex, about two inches across the wings, which are dusky beneath, the body and thorax yellow: the female is larger, and dull yellow with orange on the fore-wings, hind ones brown. The larvæ are long white grubs with distinct brown head, found during the winter in hop-stocks and devouring the roots of grass, where they are extremely difficult to destroy.

The Hepialidæ suffer from a fungoid disease caused by *Cordyceps entomorhiza*, which grows out of the caterpillar, after having invaded it internally and killed it (fig. 101).

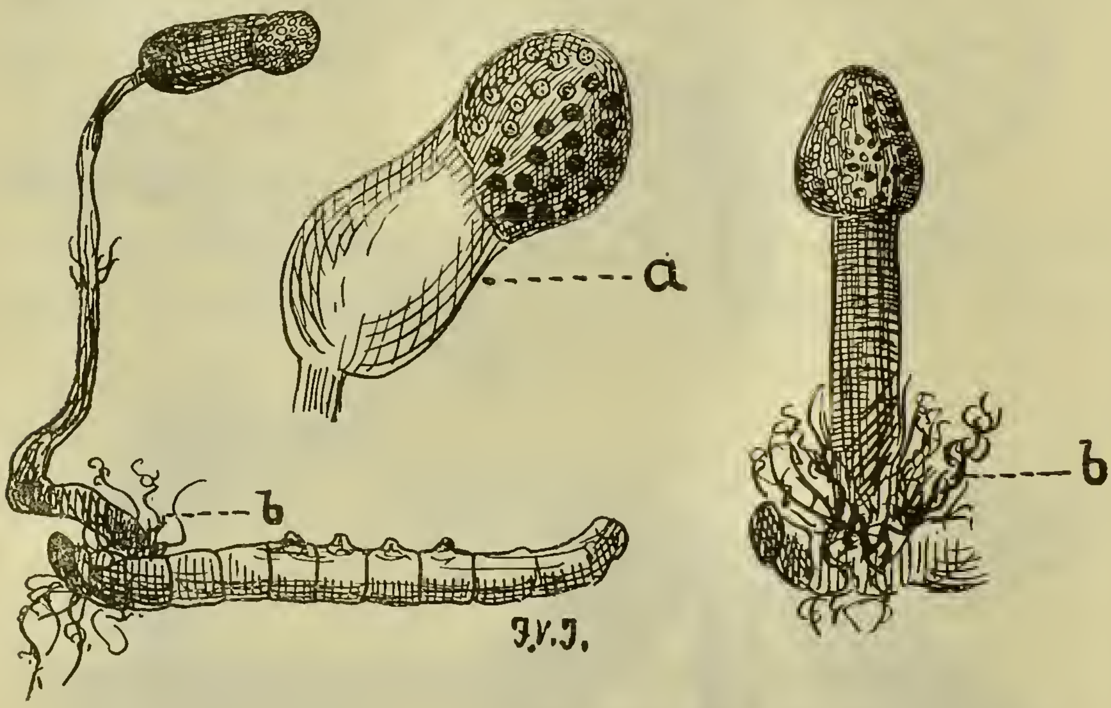

Fig. 101.—Cordyceps entomorhiza (a fungus on Hepialus larvæ).
a, Fruit; *b*, mycelium.

Bombycina.—The "bombyces" are mostly clumsy, heavy-bodied moths, with a very hairy covering to their abdomen and thorax. The antennæ in the male are pectinated. The wings are broad and tectiform when at rest. The females are generally larger than the males; some are wingless, as in the Vapourer Moth (*Orgyia antiqua*). The larvæ are usually very hairy, and many spin a light cocoon in which they pupate. The pupæ are never found underground. The larvæ of some species are gregarious, spinning large tents of silk under which they live

(Lackey Moth); others—the *Psychidæ*—form cases of foreign objects in which to live. There are several very injurious species in this division, but it also includes the valuable groups of Silk-worms (*Saturnidæ* and *Bombycidæ*). The family *Liparidæ* contains the destructive Gypsy Moth (*Liparis dispar*), whose larvæ have been such a scourge in Massachusetts and other parts of the United States, into which country it was introduced from Europe.

The Lackey Moth (*Bombyx* (*Clissiocampa*) *neustria*).

The Lackey Moth (fig. 103), one of the family Bombycidæ, is often injurious to a serious extent in our orchards. The female moth is about an inch and a quarter in expanse of wing, and brownish-red in colour, with a pale stripe on each wing: sometimes the stripe is darker than the ground-colour of the wing.

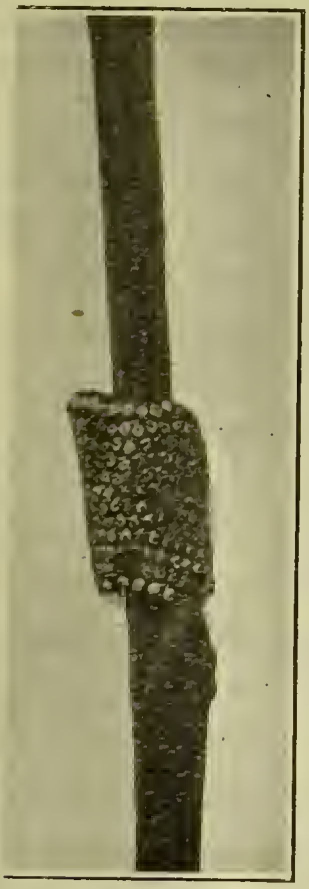

FIG. 102.—EGG-BAND OF LACKEY MOTH. (Twice nat. size.)

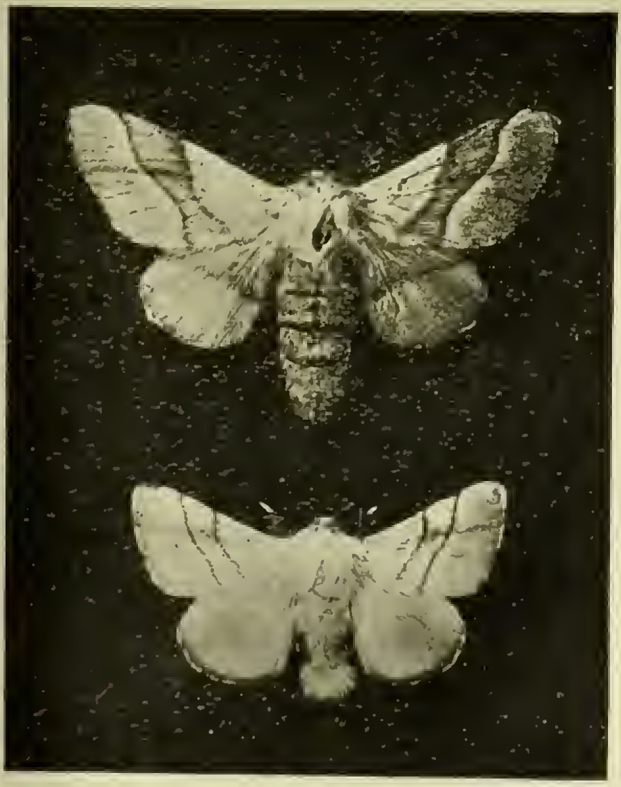

FIG. 103.—FEMALE AND MALE LACKEY MOTHS.

moth, in the male sex, about two inches across the wings, which are dusky beneath, the body and thorax yellow: the female is larger, and dull yellow with orange on the fore-wings, hind ones brown. The larvæ are long white grubs with distinct brown head, found during the winter in hop-stocks and devouring the roots of grass, where they are extremely difficult to destroy.

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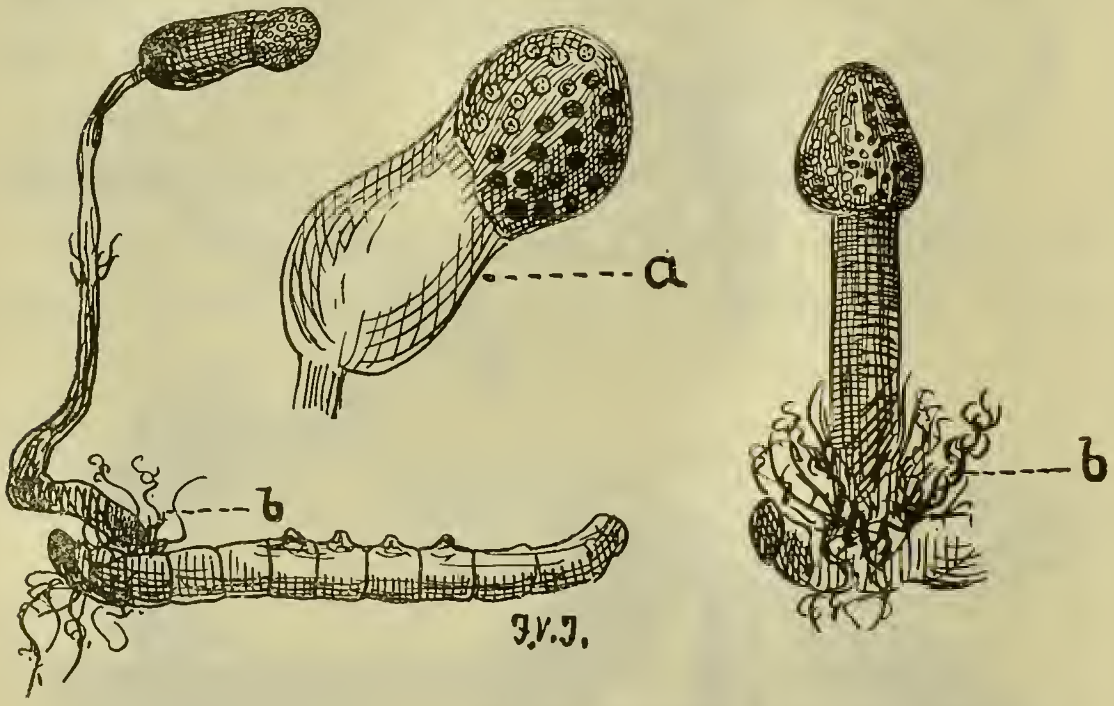

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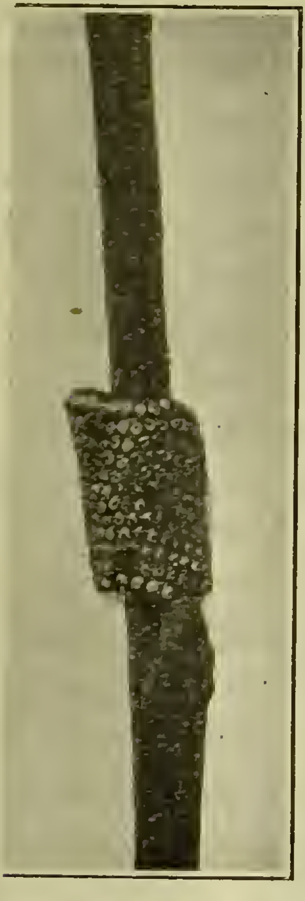

Fig. 102.—Egg-band of Lackey Moth. (Twice nat. size.)

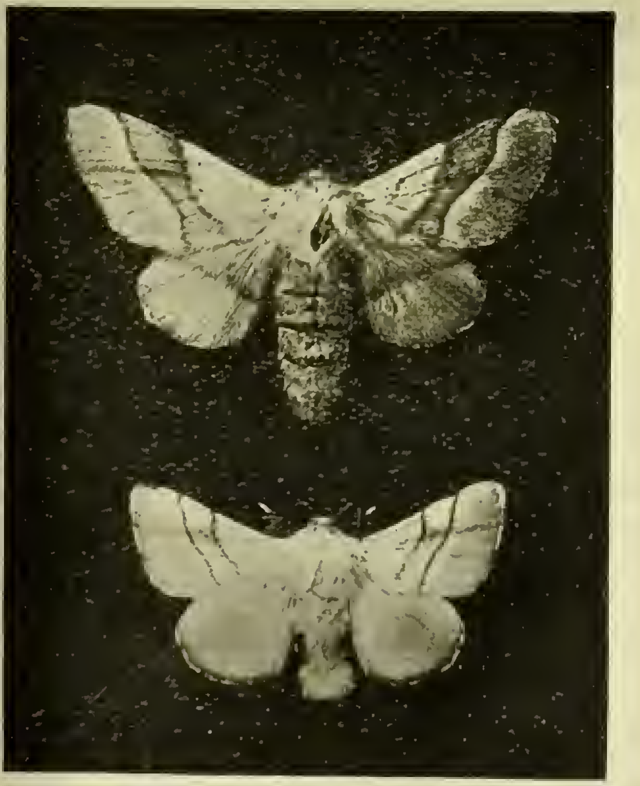

Fig. 103.—Female and Male Lackey Moths.

The male is more of a yellowish-brown colour, and smaller than the female. The adults appear in July and August, and the female lays her eggs in bands (fig. 102) tightly fixed round the smaller twigs and stems of the apple and other fruit-trees : these ribbon-like egg-bands remain on the trees all the winter, often becoming loose, so that the whole band can be turned round like a ring. The larvæ hatch in April and May, and live for some time under a tent of silk in large companies. As they grow they spread out over the tree. When mature they reach nearly two inches in length, and are bluish-grey in colour, striped longitudinally with orange-red, and between the two lowest bands a broad blue stripe on each side with little black specks, these brilliant lines being separated by black and black spotted with blue; a pure white line runs down the back, with a narrow dark line on each side. The head is bluish, with two black spots and two on the segment next the head ; body with tawny hairs. They spin a loose cocoon of white or pale yellow silk amongst the leaves, from which the moth emerges in July and August. The tent of silk sometimes reaches a foot in length.

Remedies.—Wash with arsenate of lead. In France they cut the tents down with long-handled shears and burn them ; or they can soon be destroyed, like wasp-nests, by blowing them down with a blank cartridge. The eggs are too hard to be affected by any winter wash, but the bands should be pruned off and destroyed in winter.

The **Notodontidæ**, another family, contains the well-known *Puss Moth* (*Cerura vinula*), which lives upon Willows and Osiers, sometimes causing them much loss of leafage. The large hairy moth is greyish-white, with black wavy markings, three inches in expanse of wing in the female, smaller in the male. The curious larvæ are provided with two protrusible red tails, which can be extended some distance and waved about to frighten off the Ichneumon flies that prey upon them.

Noctuina.—The Noctuæ are all, or nearly all, nocturnal in habits. They are mostly dull-coloured insects, with thread-like antennæ in the female, pectinate in the male. The abdomen is broad, but slightly tapering to a point at the hind end in the female, expanded in the male. The legs have strong tibial spurs. The front wings are generally narrow, and usually darker than the under-wings. The posterior pair are often coloured, as we see in the Red and Yellow Under-wings. The moths have a long trunk and projecting palpi. There is a great superficial resemblance between many of the species. The larvæ are but slightly hairy, and are provided with sixteen legs. If the *Plusiadæ* are included in this group, the number of legs must not be taken as a characteristic, as they are reduced to fourteen, and some forms have only twelve. The pupæ (fig. 104, 4) of Noctuæ are generally found underground. Some are naked, others surrounded by a case of earth in the soil: they are brown in colour, and devoid of body spines. Many of the larvæ, especially of the genus *Agrotis*, are called Surface Larvæ.

Surface Larvæ (*Noctuæ*).

One is constantly finding dull-coloured caterpillars in the soil, especially in the autumn, winter, and spring. These sluggish larvæ (fig. 104, 2) can at once be identified as moth larvæ by the number of their legs. They are of a variety of species: the majority, however, belong to the two moths called the Turnip Moth (*Agrotis segetum*) and the Heart-and-Dart Moth (*A. exclamationis*), while not a few are the caterpillars of the Yellow Underwing (*Triphæna pronuba*). All these are nocturnal feeders, living just under the soil during the day and coming out at night to feed. They sometimes, like worms, pull a number of leaves into the soil to devour during the day. Almost all plants are attacked by them, and the damage they cause is often considerable. Both stem and leafage is eaten, especially of young plants, alike in garden and field. The damage is often attributed to other animals, as they are not seen during the day. Celery in some places is attacked by them; the culprits have been thought to be rabbits. The two commonest moths named above have thick hairy bodies, and measure over an inch and a half across the wings—the upper ones in *A. exclamationis* being brown with dark-brown marks on them, the lower pale-brown. *A. segetum* is paler in colour.

Remedies.—Wheat-fields are often ravaged by these pests, and all we can then do is to apply nitrate of soda. Hand-picking in the day-time by turning over the soil around plants that look to be flagging is worth the trouble, even in large cabbage-fields, where they often are very destructive. After the crop has been taken, it is a good plan to turn a number of fowls on the land, as they devour these larvæ greedily; but for wholesale purposes there is nothing like a dressing of vaporite. These so-called "Cut-worms" may also be destroyed by placing here and there small heaps of clover or lucern soaked in arsenate of lead, or even bran treated in the same manner.

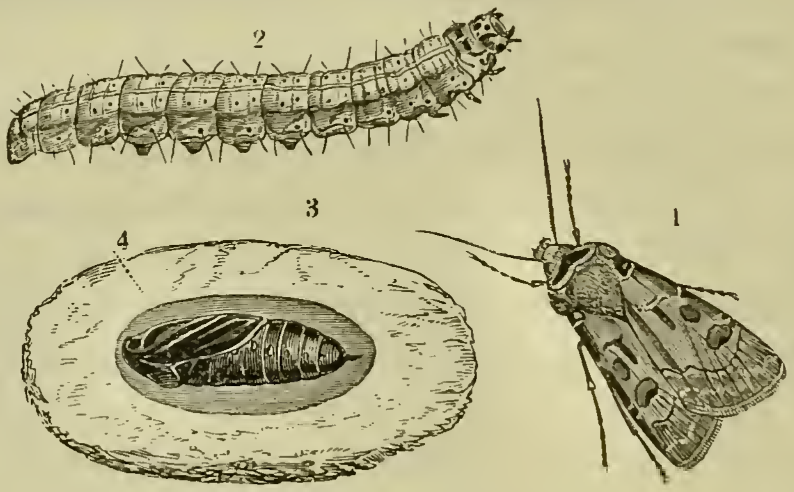

FIG. 104.—HEART-AND-DART MOTH (*Agrotis exclamationis*).
1, Imago; 2, surface larva; 3 and 4, chrysalis in earthen case. (Curtis.)

The *Plusiadæ* or Y-Moths include one destructive species—namely, the Silvery Y (*Plusia gamma*) (fig. 105), which now and then damages turnips and clover. The larvæ have only two pairs of prolegs in the middle of the body; they are green in colour, with a white streak down the back and a yellow one on each side. The Plusiadæ spin a light silken cocoon (3).

Geometrina. — The Geometers are characterised by the peculiar mode of progress in their larvæ, which have only ten or twelve legs; the prolegs are never all developed. Very few have twelve legs, fewer still are provided with fourteen. They crawl in a series of "loops," arching the body as they move. When stationary they are attached by the anal prolegs, generally with the body straight out. They often assume the colour and appearance of the stems and leaves they are found upon: this protective coloration is so marked in some species as to render them almost indistinguishable. Doubtless this mimicry is to protect them from their enemies, birds and the parasitic Ichneumon flies. The moths have slender bodies and large delicate wings, often beautifully coloured. The pupæ are found both under and above ground, and may or may not be enclosed in a cocoon. Most Geometers are crepuscular, but some fly during the day. They are mostly light bodied, and sit with their wings extended in repose, a few with the wings erect like butterflies. Some are

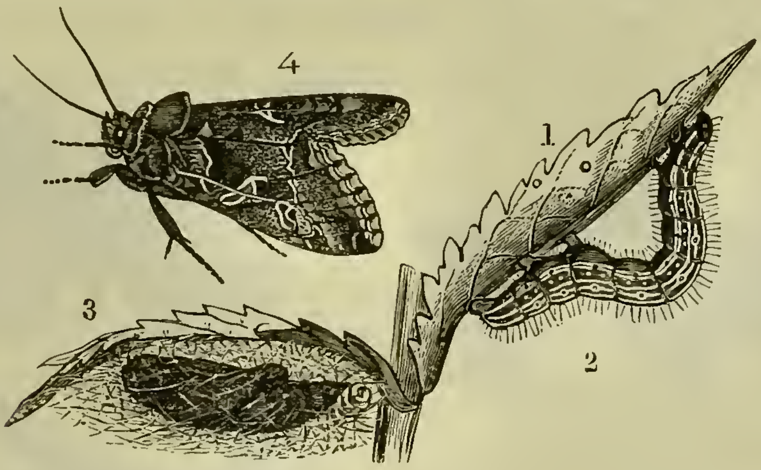

FIG. 105.—SILVERY Y-MOTH (*Plusia gamma*).
1, Ova; 2, larva; 3, pupa; 4, imago. (Curtis.)

extremely injurious to fruit-trees, of which the following are the most important.

The Winter Moth (*Cheimatobia brumata*).

This and the closely related Mottled Umber Moth (*Hybernia defoliaria*) are often a serious trouble to fruit-growers. The larvæ devour the buds, leafage, blossom, and fruit of the trees. An orchard attacked by these pests presents a scorched appearance, the leafage in some cases being completely stripped, as bare as in winter. The female Winter Moth is nearly wingless, and, to lay her eggs, ascends the trunk of the tree on hatching from the pupa in the ground or amongst the grass beneath the trees. The male is winged, about an inch and a quarter in expanse, brownish-grey with wavy brown lines across the front pair. They fly about at dusk, sometimes carrying the female *in copulâ* to the boughs to deposit her ova. They are called "Winter Moths" because they appear during the cold months of the year, from October to January. The green looper-larvæ hatch from the ova in the spring about the time the buds are ready to burst. They pupate in and on the

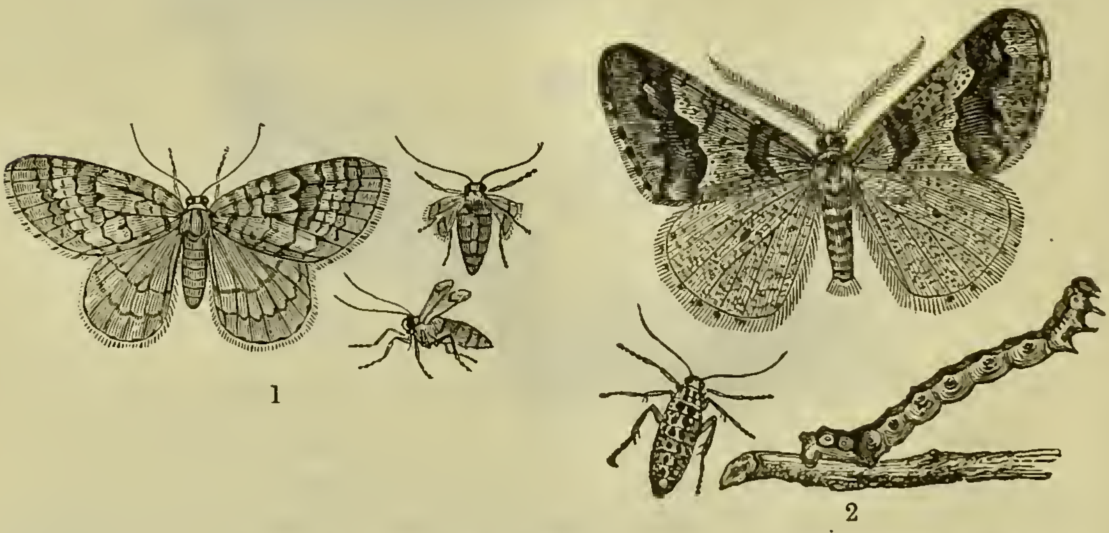

FIG. 106.—1, WINTER MOTH (*Cheimatobia brumata*). 2, MOTTLED UMBER MOTH AND CATERPILLAR (*Hybernia defoliaria*).

Male moth, winged; female moth, wingless. (All natural size.)

ground when mature, which is about June. The larvæ are at first dark grey ; as they grow they change to green, with pale stripes along their body. They spin the leaves and blossom together. When mature they measure an inch in length. Lowering themselves down by a cord of silk, or falling, they then form a cocoon which is covered outside with earth, and hatch out in the late autumn and winter.

The moths lay their eggs close to the buds : they are small green bodies at first, changing to red before they hatch, and are clearly visible to the naked eye. Other allied species with wingless females and doing similar damage are the March Moth (*Anisopteryx æscularia*) and the Mottled Umber Moth (*Hybernia defoliaria*). The March Moth appears in the early spring, and lays her eggs in bands round the twigs. The female is quite wingless, so is the female Mottled Umber.

Prevention and Remedies.—Bands of grease-proof paper, smeared with grease, put round the trees in October and kept on until March, is a method generally employed for catching the wingless females. A few nevertheless may escape this trap, so that washing is sometimes necessary. A special preparation called Tanglefoot is best to use, as it lasts sticky for nine months, and can be put on the bark direct, except on Peach trees. Arsenate of lead is the best wash for Winter Moths.

Magpie Moth (Abraxas grossulariata).

Another Geometer is represented by the Magpie Moth (*Abraxas grossulariata*), whose black and white "loopers" devour currant, nut, apricot, and other leaves. Unlike the Winter Moths, the Abraxas larva spins a very slight case of silk, in which the "looper" is transformed into a black-and yellow-banded pupa upon the currant-bushes, &c., and neighbouring walls and fences, always above-ground. The moths have a wing expanse of two inches ; they are creamy white, spotted and banded with black and yellow; we may see them in almost any garden in July and August, flying lazily about over the currant-bushes at dusk. The eggs, which are oblong yellowish bodies, are laid upon the leaves. The young larvæ are almost black, and go on feeding until the foliage gets too dry, when they repair to their winter quarters, in the crevices of walls, amongst the dead leaves that collect at the forks of the bushes, and other places: they are at this time about a quarter of an inch long, and dark in colour. As soon as the currants show leaf in the spring, they come forth and commence to feed again, and at this period they do most harm. Eventually, about the middle of June they reach an inch and a quarter in length, and are black and white, with orange markings at the sides,—the pupal stage lasting until July and August.

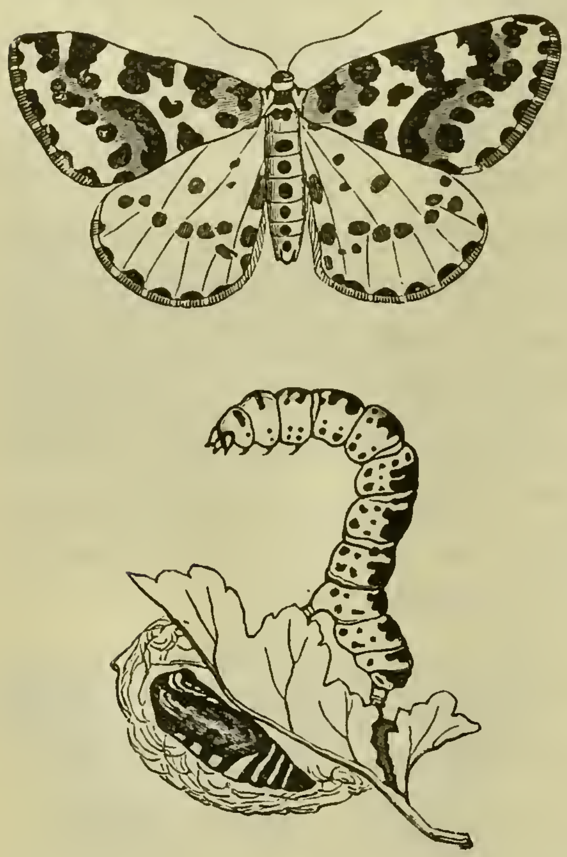

Fig. 107.—Life-history of Currant or Magpie Moth (*Abraxas grossulariata*).

Remedies.—Destruction of winter shelter and early spraying with arsenate of lead will keep this pest well in hand.

Microlepidoptera.

The Microlepidoptera are all small moths, many very minute. The antennæ are thread-shaped. There are two chief sections: (i) Tortricina; (ii) Tineina. There are several important families, containing some species of economic importance, especially the *Tortricidæ*, *Carpocapsidæ*, *Plutellidæ*, and *Tineidæ*. The *Pyr-*

alidæ are also included in this group; they have long and narrow wings, short palpi, and long-pointed abdomen, reaching far beyond the wings. Their larvæ are shiny, and often have a few scattered hairs over the body. Some pupate in cocoons, others like butterfly larvæ. One species, the Garden Pebble-Moth (*Pionea forficalis*), is sometimes injurious to garden produce, otherwise they are of little economic importance. The *Crambidæ* form another family popularly called "grass moths"; they have long wings and long palpi, the front wings narrow, the hind ones ample and broad. In the true *Crambidæ* the wings fold up in a tubular form when at rest. One family, the *Galeriidæ* or Bee-Moths, are injurious to bee-keepers, for their larvæ live in the comb and weaken the stock. Improvements in apiculture have, however, done away with the loss from this pest.

The **Tortricidæ** and **Carpocapsidæ** are most important. These insects have a narrow body, not extending beyond the hind-wings. Fore-wings short and broad, truncate at the extremity, hind-wings also broad. The larvæ live very often in rolled-up leaves; others live in seeds and fruit, and in the flower-heads of plants. Most of the larvæ are pale in colour, delicate in texture, and slightly hairy, with a large brown head.

The Codling Moth (*Carpocapsa pomonella*).

The members of the genus *Carpocapsa* live inside seeds and fruits in the larval stage. The Codling Moth is one of the *Carpocapsidæ*, is half an inch across the wings; the fore-wings are grey, with dark wavy lines, and a metallic patch at each corner; the hind-wings are slaty grey. They appear in the orchards soon after the blossom has fallen from the apple-trees, when the female deposits her eggs on the side of the young fruit. The minute Codling maggot enters the apple at the calyx, and then commences to burrow into the fruit, where it matures, causing so-called "maggotty" apples and "early windfalls." They first burrow to the centre and then to the outside, where they form a large hole through which the "frass" is passed out. The maggot devours the core. When mature, the larva is a little more than half an inch long, pale pinkish white with scattered hairs over it, and the usual number of legs. On reaching the full-grown stage the maggot leaves the apple: if the fruit remains still on the tree it lowers itself down by a thread of silk to the ground, or crawls down; often the apple has fallen by the time the larva is full fed. The majority reascend the tree and spin cocoons of dirty-white silk beneath the bark, in which they turn to chestnut-brown pupæ. Some larvæ remain as such in the cocoon until the spring, others pupate in the autumn. In America there may be three or more broods, but in Britain it is usually single brooded. All kinds of apples are attacked, no variety being immune as far as is known. This pest is found all over the world. It has been distributed in fruit. In many cases it is accountable for the loss of quite half of the crop, especially in badly kept orchards. Pears are also attacked.

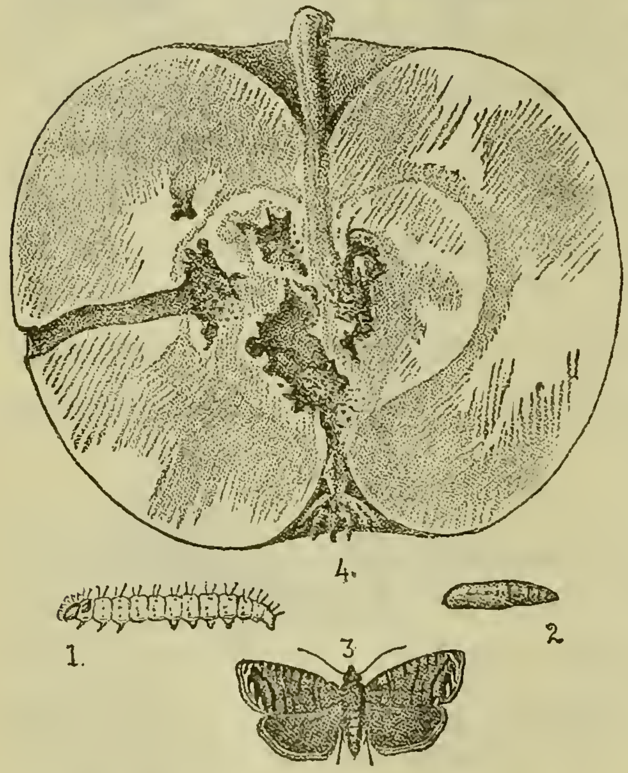

Fig. 108.—Codling Moth (*Carpocapsa pomonella*).

1, Larva; 2, pupa; 3, imago; 4, diseased fruit.

Prevention and Remedies.—This pest is one of the easiest to prevent and destroy if taken in time. It is surprising how many larvæ can be trapped by tying a band of cloth round the tree trunks close to the ground: the ascending caterpillars here find shelter and pupate; the bands can be taken off in the winter and burnt with the cocoons in their folds. Many, however, change on the ground, especially if rough grass grows beneath the trees; this should all be destroyed in the winter. Fowls and pigs turned into the orchards in late summer do much good in lessening their numbers. Spraying with arsenate of lead directly the blossom has fallen kills the larvæ as they enter the apple, for their first bite is arsenic that has lodged in the calyx. Needless to say, cleaning off rough bark and destroying it in winter is beneficial, for by so doing many cocoons are destroyed.

Another noxious Tortrix is the Pea Moth (*Grapholitha pisana*), whose larvæ inhabit pea-pods, living partly in the peas and so spoiling their market value: this small slaty-grey moth is not half an inch across the wings. The female lays her eggs in the quite young pea-pod before it is properly formed.

A great number of Tortrix larvæ feed on apple, pear, and plum, spinning the leaves and blossom together.

The commonest species found are *Tortrix ribeana*, *T. heparana*, and *Penthina pruniana*. Several others also occur in great numbers amongst fruit foliage.

Tineinæ are small moths, having long narrow wings with long fringes of hairs (fig. 110, D). Some are very small. At least one-third of our British moths belong to this group. The larvæ vary in regard to the number of their legs; sixteen is the usual number, but in the genera *Gracilaria*, *Lithocolletis*, &c., there are only fourteen, whilst in *Nepticula* there are eighteen; in *Antispila* the larvæ are quite apodal. The larvæ vary as much in habits as in structure: some are miners, forming fine tunnels in leaves; some roll up leaves; the *Coleophoridæ* live in peculiar cases almost like snail-shells (fig. 110, A); clothes form a shelter for one group, and numberless others live in a variety of ways. Amongst the injurious species we must at least mention the well-known

Diamond-back Moth (*Plutella maculipennis*).

In 1891 the east coast of Great Britain was ravaged by countless numbers of this moth, whose larvæ feed on turnip, cabbage, and most other cruciferous plants, devouring the leaves down to the midrib. It was estimated that in a single year this little pest, which is well known over most parts of England, caused £20,000 worth of damage to root-crops alone. Before that year and since it has done harm in many districts. The moth, which is a native, has long narrow wings, the fore pair being reddish- or slaty-brown, with a pale yellowish-white border posteriorly; the hind-wings are grey, with long fringes of hair, a feature seen in all Tineinæ. When the wings are folded the pale edges of the front ones come close together, and form diamond-shaped areas, hence its popular name. The moths (fig. 109) appear in June and July, and lay their eggs on the under-side of the leaves. The larvæ are at first grey, then green in colour, about half an inch long when full-grown: they feed ravenously on the under-side of the leaf. When frightened by any shock they drop off, hanging by a silken cord, which they use to regain the leaf when the supposed danger has passed. In from four to five weeks the larvæ are mature, and then spin a network-like tube of loose yellowish silk on the leaf, blocking up one end with their cast skin and covering the other with a few threads. Inside a black and greyish-white pupa will be found. As pupæ they

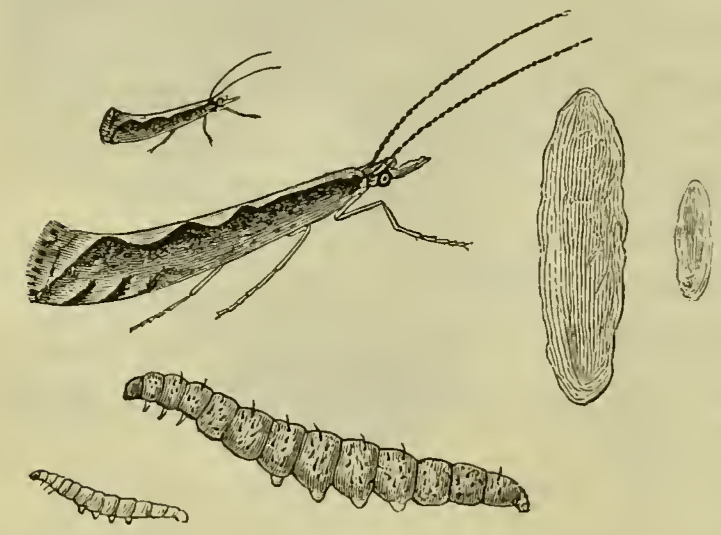

Fig. 109.—Diamond-back Moth (*Plutella maculipennis*).
Moth, larva, and cocoon (nat. size, and magnified).

remain from two to three weeks. There are two broods in the year in most places—the winter being passed in the pupal stage on dead leaves, &c.

Remedies.—This is an extremely difficult pest to cope with, as it feeds on the under-surface of the foliage. But their habit of falling off the leaf when disturbed puts them to some extent under our control. An ingenious plan used by a Yorkshire farmer was to attach boughs to the nozzles of the "strawsoniser" in front, so that the silken cords of the larvæ are broken, and they then fall to the ground and are reached by the insecticide used. Paraffin emulsion is as good as any to spray with. Where no "strawsoniser" can be got, taking the "scuffler" through the roots with supple birch or broom twigs attached will knock the larvæ off; a little plough following after will kill the pests as they lie on the ground. It was noticed in 1891 that the caterpillars all suddenly disappeared after a heavy rainstorm. Most larvæ of moths are unable to stand a heavy downpour. Luckily a number of Ichneumons prey on this pest, and help to keep its numbers down.

The Cherry-tree Case-bearer (*Coleophora anatipenella*).

The *Coleophoridæ* are all very small Tineinæ, with greyish pointed wings fringed with long hair. Their larvæ live in variously formed cases, by which they may very easily be identified. *C. anatipenella* appears in July and August, and lays her ova upon the leaf of the cherry- and apple-trees. The young larvæ soon commence to form a case, which in this species is pistol-shaped, dark-brown with a white border around the opening (fig. 110, A). In form it is something like a snail-shell. The larvæ live inside these cases on the leaves, and eat away the tissue in the same way as the pear slug-worm. They grow slowly, and remain on the stem and boughs of the cherry-trees all the winter. The case is so like the colour of the bark that they are then very difficult to detect. The larvæ pupate in these cases, and then remain closely attached to the leaves or the twigs. They move slowly, the larva putting its head

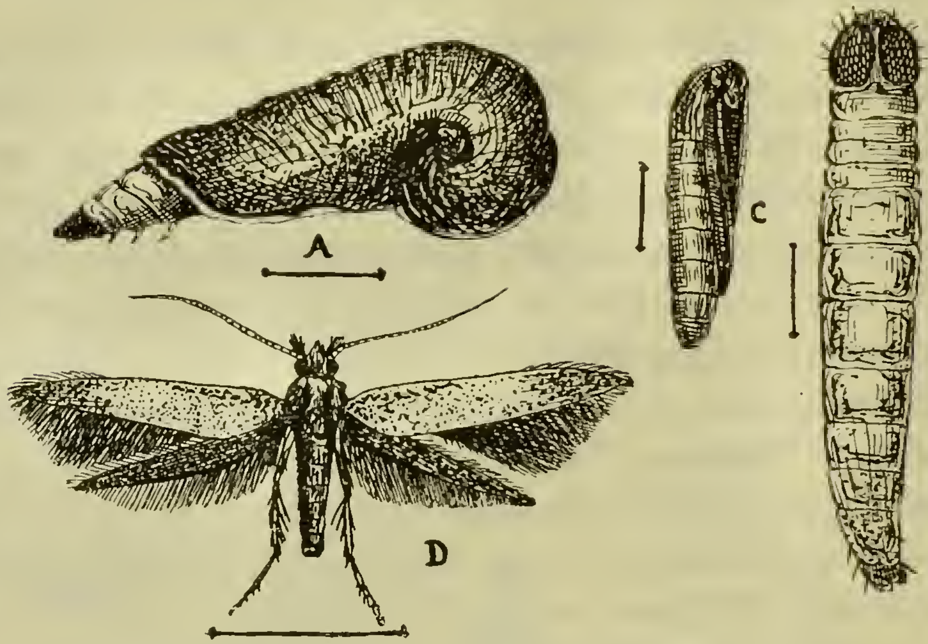

Fig. 110.—Cherry-tree Case-bearer (*Coleophora anatipenella*).

A, Larva in case; B, larva free; C, pupa; D, adult.

and three front segments and six legs well out when crawling about.

Remedies.—Arsenical washes soon kill them; no contact washes have any effect, as they are protected by their so-called "houses."

The Raspberry Shoot-borer (*Lampronia rubiella*).

Raspberry shoots are often attacked by the larvæ of one of the Tineinæ. This moth comes out the end of May and in June, and lays its eggs in the flowers; from these hatch the larvæ, which feed in the core of the berries, which they leave before ripe and fall or crawl to the ground. They then find shelter and spin a flat white cocoon $\frac{1}{12}$ inch in diameter. These cocoons are generally under the rough rind of the canes, or in cracks and crevices, stones, &c. In the spring they come forth and bore into the shoots, where they pupate in May. The shoots thus die, especially the young ones, and wither up. The larva is red, with a black head, with the second segment brown above, about $\frac{1}{4}$ inch long. The moth is about $\frac{1}{2}$ of an inch in wing expanse; the fore-wings are shiny brown with yellow dots, two being large spots on the inner margin and four smaller ones along the costa.

Prevention.—After a bad attack of *L. rubiella* it is advisable to cut back the canes and burn them, and let them make a fresh growth next year. Applications round the stocks in the early spring, of soot and lime or paraffin and sand, are said to do some good: poles with the rind on should always be avoided, as they harbour the larvæ in the winter. As many larvæ ascend the canes in spring, smearing grease over them in March has been found useful.

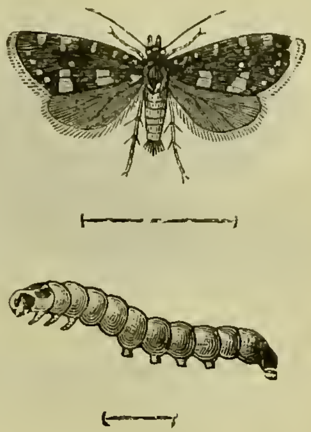

FIG. 111.—RASPBERRY SHOOT-BORER (*Lampronia rubiella*), imago and larva.

Another species, *Incurvaria capitella,* or the Currant-borer, works on currant shoots and also on the fruit. The moth is dark brown with a purplish tinge, with a pale yellow band near the inner margin of the wing and two yellow spots on the fore-wings. The eggs are laid in May, in the young fruit in which the larvæ live until the fruit is destroyed. They then pass out and form a cocoon on the wood and in crevices, and remain there until the following spring, when they enter the shoots. The larva is greenish, with a red patch on the 9th segment and black 2nd segment.

The Pear-leaf Blister Moth (*Cemiostoma scitella.* Zeller).

Amongst the Tineinæ are many which tunnel into foliage when larvæ: some form long galleries, as the Rose-leaf Miner (*Nepticula anomallella*); others round blisters, as seen in the Pear-leaf Blister Moth (fig. 112). This moth appears in

May or even the end of April, and then again in late June and July into August. The moth has leaden-grey wings with a brownish-grey streak running from the costa obliquely across the wing; two white streaks also run from the costa, nearer the tip, separated by a coppery band, which runs half across the wing; beneath there is a black spot with a violet pupil, and the fringe has four radiating dark lines; hind wings leaden-grey, length $\frac{1}{4}$ inch, eggs laid under the leaves, and the larvæ enter the tissue and form the brown circular blisters; they are $\frac{1}{4}$ inch long with four pairs of curious lateral processes. When mature they crawl out and spin a cocoon in crevices in the bark and even in the soil. The cocoons are of white silk. It remains as a pupa all the winter. Apple is also attacked, and Hawthorn.

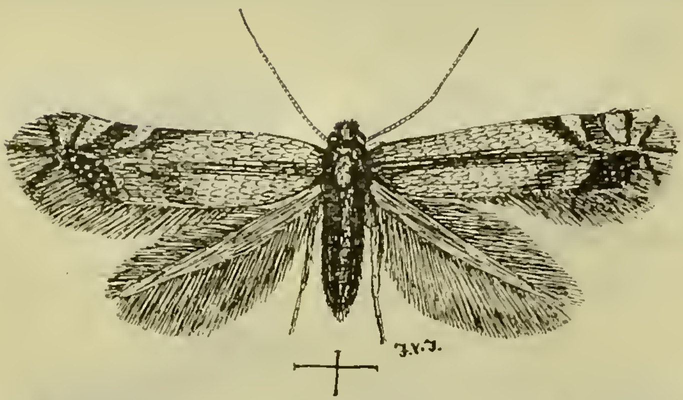

Fig. 112.—The Pear-leaf Blister Moth (*Cemiostoma scitella*).

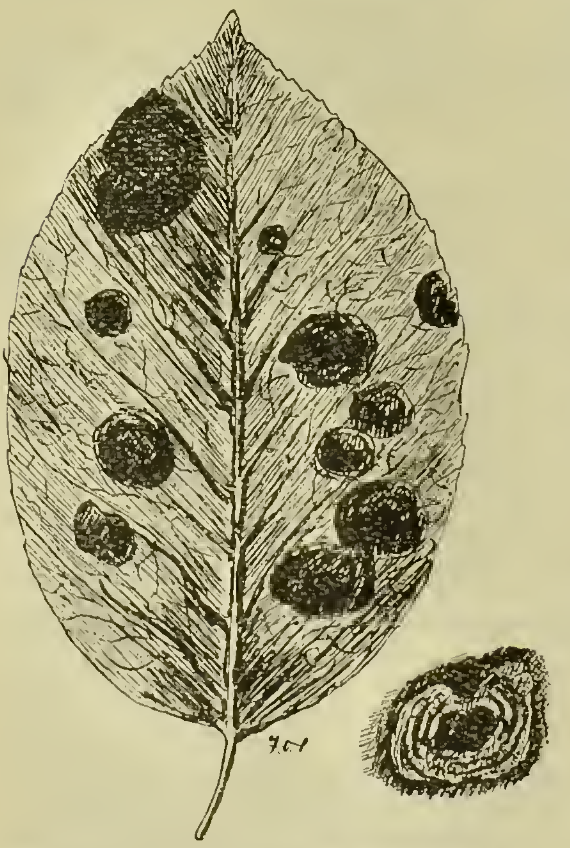

Fig. 113.—Pear Leaf blistered by *Cemiostoma scitella*.

Attacked leaves should be hand-picked.

A number of Tineinæ attack stored corn, especially in mills, such as the Corn Moth (*Tinea granella*) and the Mediterranean Flour Moth (*Ephestia kühniella*), but they are of little concern to the farmer, fruit-grower, and gardener.

DIPTERA,

OR TRUE FLIES.

The Diptera form the last order of insects with a complete metamorphosis. They can easily be identified by the presence of a single pair of wings—the posterior or second pair being reduced to two club-shaped processes called "balancers," "halteres," or "poisers" (fig. 114). The two anterior wings are flat membranous expansions, never completely covered with scales, although they are present in mosquitoes (*Culicidæ*) (fig. 115) and a few gall-flies (*Cecidomyidæ*). Hairs are often present on the wings, both upon and around them. Some Diptera, such as the fleas (*Pulicidæ*), fig. 148, and the Sheep-ticks (*Melophaga*), fig. 146, are entirely apterous. In regard to the mouth parts of Diptera there is also much variation: some have sucking mouths

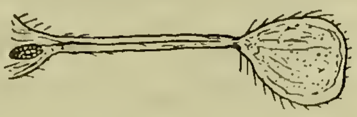

FIG. 114.—HALTERE OF A FLY.

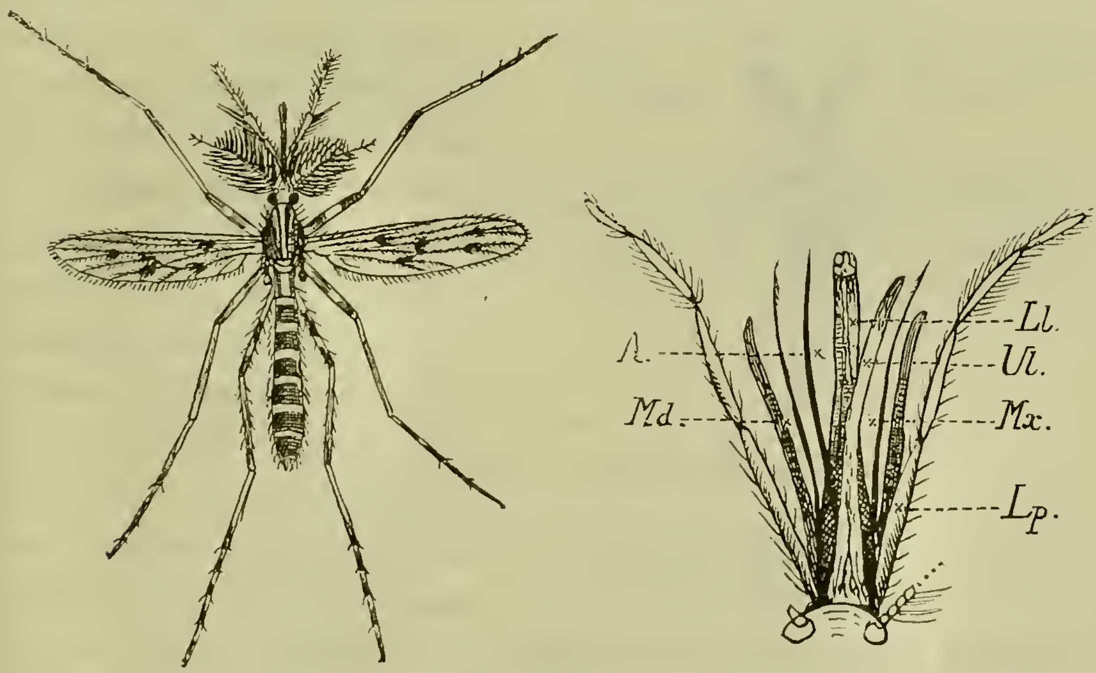

FIG. 115.

A MOSQUITO (*Theobaldia annulata*), ♂. (Enlarged twice.)

HEAD OF A MOSQUITO (Piercing mouth).

A, Hypopharynx; *Ll*, lower lip; *Ul*, upper lip; *Md*, mandible; *Mx*, maxilla; *Lp*, palpi.

(*Bombylius*), others piercing mouths (*Tabanus* or the Gad-fly), fig. 126; in the Warble-flies (*Œstridæ*) the mouth is rudimentary, the adults taking no nourishment. There is never a sting; flies wound by piercing with the mouth, but not, as is often supposed, by stinging. The labium of the mouth (fig. 115, *Ll*) is greatly elongated, and forms a kind of gutter for the reception of the lancet-shaped maxillæ and mandibles. The proboscis, made up of the labium, &c., ends in a fleshy swollen tongue, and is closed above by the labrum. There are no true labial palpi, but the processes at the tip of the labium called *labellæ* are thought to represent them. The head is large, and united to the thorax by a very short neck. The thorax is large and compact, the prothorax closely united to the mesothorax, and forming a thin collar or two lobes. The eggs of flies are usually oval or spindle-shaped bodies, of a white or black colour, sometimes laid singly, at others in groups. The larvæ are mostly white footless maggots; no true legs are ever present. Thirteen segments is the usual number present, but in some fourteen may be found (fig. 117, A). The head may be horny and complete, or may be reduced to a simple pair of hooks, the mandibles (fig. 132, D); the body may be naked (fig. 117, A) or bristly (fig. 133, 7). Most are terrestrial, but some have aquatic larvæ—*Culicidæ* (Mosquitoes), *Chironomidæ* (Midges) (fig. 116), and *Eristalidæ* (Rat-tailed Flies). The genera *Volucella*, *Tachina*, and *Conops* are parasitic in their larval stage on other insects; the genera *Hypoderma*, *Gastrophilus*, *Œstrus*, *Lucilia*, and *Sarcophagus*, &c., on vertebrates. When mature, dipterous larvæ may or

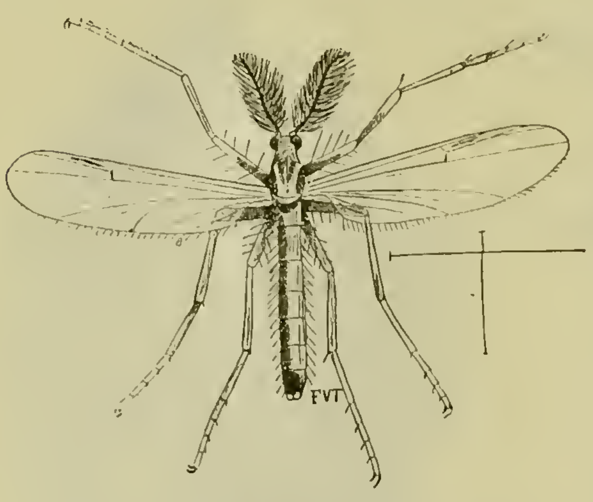

FIG. 116.—PLUMED GNAT (*Chironomus plumosus*).

may not cast off the larval skin. The naked pupæ (fig. 117) are very varied, often armed with spines and bristles (fig. 124, 5). Those that retain the larval skin as a case form so-called "puparia," the true pupa being found in the brown case, formed of the maggot's old skin much hardened (fig. 65, A, i. and ii.).

Diptera are divided into two large sections, the *Orthorrhapha* and the *Cyclorrhapha.* The first have their larvæ with a distinct chitinous head, and their pupæ escape from the larval skin by a T-shaped rent; the second have no chitinous head, and the pupa or imago escapes from the larval skin by a circular opening.

There are two divisions in the *Orthorrhapha*—the *Nematocera* and the *Brachycera,*—the former with thread-like many-jointed antennæ, the latter with antennæ composed of two or three large basal joints with a multiarticulate bristle (fig. 145, *a*). Lastly, there are the *Pupipara,* which produce their young in a fully matured state as puparia.

There are many flies extremely harmful to the agriculturist and gardener. Some carry diseases from man to man and animal to animal (Mosquitoes and Malaria, Tsetse Flies and Sleeping Sickness).

Cecidomyidæ, or Gall-Gnats.

This family contains only small flies, some of which are distinctly harmful, such as the Hessian Fly (*Cecidomyia destructor*), the Wheat Midge (*Diplosis tritici*), and the Pear Midge (*Diplosis pyrivora*). The Cecids have very few veins in their wings, hairy antennæ, and often hairy wings. The larvæ are sometimes white, at others red in hue, and composed of fourteen segments. They always have on the under surface, close to the anterior extremity, a curious process called the Breast Bone or Anchor Process (fig. 118). Many larvæ form galls, in which they live, and may or may not pupate there.

The larvæ mostly change in their old skin, which hardens and forms a case or puparium.

THE HESSIAN FLY (CECIDOMYIA DESTRUCTOR).

In 1886 there was a great scare in Britain concerning this pest, which was thought to have been introduced from America. It was not, however, but is an undoubted native species. The damage caused by this midge is very severe on the American continent; but here it only now and then makes itself sufficiently noxious to call for special attention. The adult fly is a small hairy creature, brownish in colour, with pinkish markings on the abdomen in the female, much darker in the male. It belongs to the genus *Cecidomyia*, which can be told by the venation of the wings shown in figure 119. The small reddish-white cylindrical eggs are laid by the female in rows on the

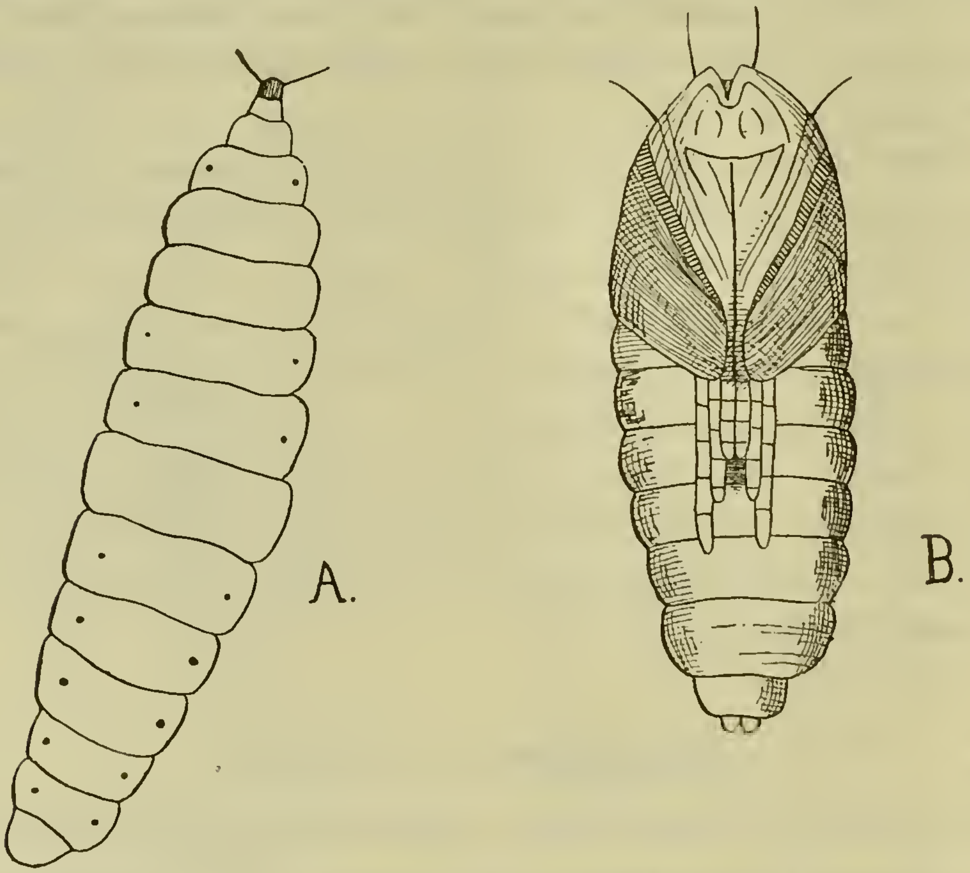

FIG. 117.—A, LARVA, AND B, PUPA OF A *Cecidomyia* (greatly enlarged).

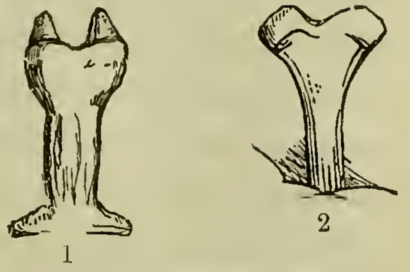

Fig. 118.—Anchor Processes.

1, Anchor process of Hessian fly; 2, of Wheat midge. (Ormerod.)

leaf of the young wheat-plants in May; the small white maggots crawl down the leaf, and bury themselves in the leaf-sheath, generally taking up their position above the second node from the ground. Here these little white larvæ feed upon the sap of the plant, and turn to the curious "flax-seed" stage, in which the larva remains in its old skin, which has hardened to form the puparium, and which resembles a flax-seed in appearance. The larvæ are at times pale green, at others tinted with red. In these flax-seeds the larva turns to a minute pale-brown pupa. These flax-seeds may remain as such all the winter, or they may give rise to a second brood of flies. This second brood hatches out in September, long before our wheat is up, and thus have to lay their eggs on other plants, such as couch and timothy grass, pupating there in the spring, and then give rise to the May brood. The presence of this pest in a field is very marked. The straw, as soon as the ear begins to develop, bends over above the second node, and looks as if weather-beaten, the grain being small, if not spoilt. In America the second brood lays its eggs on the young winter wheat, the larvæ living in the crown of the plant just beneath the ground, and causing the leaves to present an unhealthy dark and broad appearance, the central leaf usually disappearing. It is this method of attack that is the most severe, whole strips of wheat being entirely killed by it; but for obvious reasons we cannot suffer from this form of attack on our side of the Atlantic. The Hessian fly is most prevalent in the eastern counties of England, but may be found

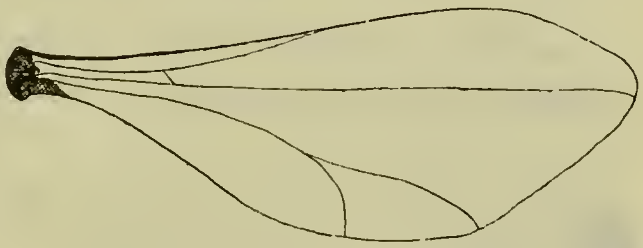

Fig. 119.—Wing of Cecidomyia.

all over the south, west, and in Yorkshire, &c. A second brood is the exception here, the insect passing the winter in the flax-seed stage, which remains very often, if the corn is not cut close, in the "gratten." Numbers may also be seen in the cavings and screenings from the threshing-machine. Wheat, barley, and rye, as well as the wild grasses mentioned, are attacked, but never oats.

Prevention and Remedies.—In those areas where *C. destructor* is very abundant it is well to use the stouter-strawed varieties of corn, and to burn the stubble after an attack by firing the borders of the fields. All infested screening should be destroyed, and light grain, which may often contain the flax-seeds as well, given to stock. The Hessian fly is subject to a number of Hymenopterous enemies. In 1888 Mr Enock bred from 1694 flax-seeds 58 more parasites than flies.

THE WHEAT MIDGE (DIPLOSIS TRITICI).

The Wheat Midge is very prevalent in England, and causes persistent loss in corn-growing districts. It is about the same size as the Hessian fly, but more delicate in structure, and yellow or orange in colour, except the eyes which are black. It belongs to another genus, *Diplosis*, whose characteristic wing venation is given in fig. 120. The female fly has quite a long ovipositor, and may often be seen in the fields in clouds, flying about low down amongst the stalks close to the ground in the daytime, when disturbed, but at sunset they come up to the ears to deposit their eggs in the florets of the wheat. The larvæ are yellowish-red in colour, and feed off the developing grains, thus spoiling them. Numbers of larvæ are found in each ear, and cause a disease generally spoken of as "red gum"

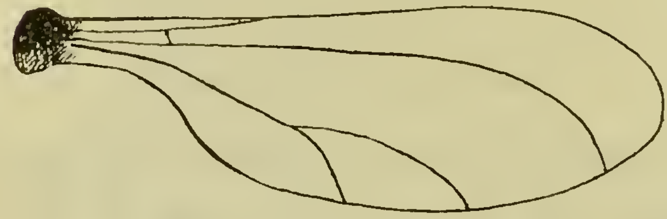

FIG. 120.—WING OF DIPLOSIS.

or "red maggot" by farmers. The larvæ mature by the time the corn is ripening, and many go down to the ground to pupate, the puparia being orange-coloured bodies. Others which are not full fed get harvested, and we find them often quite abundant in the screenings. From these puparia next June the wheat midges hatch out, and continue their noxious habits. It is strange, when collecting these flies in the field, how few males one ever sees. But, on the other hand, where heaps of machine rubbish are left about, there in June, often hovering in clouds above the heaps, males and females may be seen *in copulâ* in equal numbers. This pest is not confined to Great Britain, but is equally abundant in America. From personal observation I find the female lays about ten to twenty eggs in each ear at dusk.

Prevention.—These flies are very delicate creatures, and cannot escape through the soil unless close to the surface, where we usually find the red puparia. Therefore, deeply ploughing in the stubble in the following way cannot fail to do good—namely, by having a skim-coulter attached to the plough in such a way that it will take off an inch or so of the surface and turn it into the preceding furrow, thus burying larvæ and puparia to such a depth that they cannot escape when mature. Another important thing to do is to destroy all infested rubbish from the machines, for over those rubbish-heaps, as already said, breeding largely takes place. In America the plan of not reaping too close and burning the stubble must also do good. *D. tritici* also feeds on timothy grass and meadow cock's-foot.

THE PEAR MIDGE (DIPLOSIS PYRIVORA).

During recent years attention has been repeatedly drawn to the loss amongst pears caused by Cecid larvæ. The fly which gives rise to these was described as *Cecidomyia nigra* by Meigen, but has been redescribed and named by Professor Riley *Diplosis pyrivora*. It is destructive in America as well as in Europe. Diseased pears become distorted about the time they are slightly larger than the size of a hazel-nut, presenting a well-marked appearance by which they can be always detected. The fly (fig. 121) is a minute midge about the size of the wheat midge, but blackish-grey in colour. The female lays her eggs in the unopened blossoms, just when the petals commence to show themselves. Sometimes I have observed them oviposit in the opened blossoms. The white larvæ feed off the upper parts of the young fruit first, and by degrees turn the inside black and hollow it out: as many as sixty larvæ may frequently be found in one fruitlet. The pears are thus completely destroyed. The maggots rarely pupate inside the dead pear, which turns black and shrivels up; generally they escape into the ground. The fly is about one-twelfth of an inch long and greyish-black in colour, with pale-brown antennæ, and abdomen covered with pale hairs. Wings hairy, and halteres yellow, with white knobs. The eggs hatch in four to six days. The maggots are creamy-white, about one-seventh of an inch long, and commence to reach maturity about the first week in June. They may, I find, stay in the dead pear for some time; but eventually they get into the ground, where they form little cells to pupate in. All varieties of pears suffer to some extent.

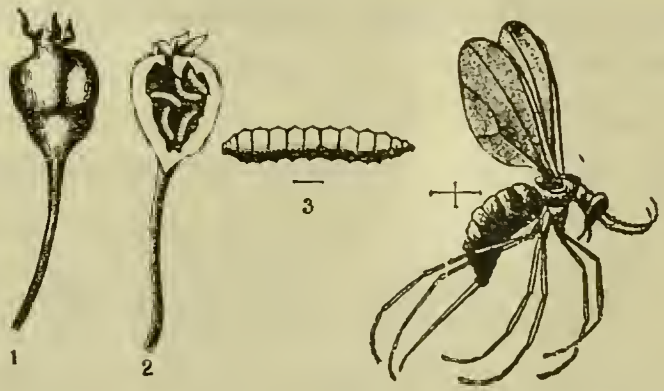

FIG. 121.—THE PEAR MIDGE.

1, Pear stunted and malformed by the larvæ within it; 2, section of pear with larvæ; 3, larva, much magnified; 4, female fly, much magnified. Lines show natural length of fly and larva. (From U.S.A. Dept. Agriculture.)

Prevention and Remedies.—As far as possible, all infested fruitlets should be destroyed, but this is not always feasible. At present the most successful preventive seems to be kainit spread under the trees after infestation, at the rate of half a ton to the acre (Professor J. B. Smith). If the kainit is used at the time the larvæ are falling to the ground, 5 cwt. to the acre is sufficient. Removal of the soil for some two inches deep and burning it in the winter would do much good where possible, but it is a troublesome and risky plan, not to be advised except in very local attacks.

THE CRUCIFER MIDGE (C. BRASSICÆ).

Another member of the same family is often injurious to turnip and cabbage seed. The larvæ of this midge live in the seeds of turnip, rape, and cabbage, in the pods. As many as sixty may often be found in one pod, which they cause to turn prematurely yellow and to burst. The fly has a black head and thorax, pinkish abdomen banded with dark-brown, and black legs which are silvery beneath. The female has a long white ovipositor, and lays her eggs in the young pods. We find the larvæ in May and June: they are white, often with a greenish-yellow stripe down the middle. They reach one-twelfth of an inch in length when mature, and fall to the ground out of the split pod and there pupate, coming forth as the second brood of flies in a few days hence. I have found it has three broods at times. Little can be done to prevent its damage, which is often severe.

Numerous other Cecids make their effects felt, but space forbids our even mentioning them here.

The **Bibionidæ** form a family of dark flies with broad bodies, short legs, and the tibiæ armed with thick spines. They frequent damp meadows, and some of the genus *Bibio* appear in great numbers. One species, the Fever Fly (*Dilophus febrilis*), sometimes occurs in hop-cones in swarms. The larvæ of the Bibionidæ (fig. 122, B) are cylindrical or fusciform maggots which live in earth, decaying stems of plants, and on the roots of plants. They are mostly saprophytic, but some (*Bibio hortulanus*, &c.) are injurious in their larval stage to hop roots and those of many garden plants.

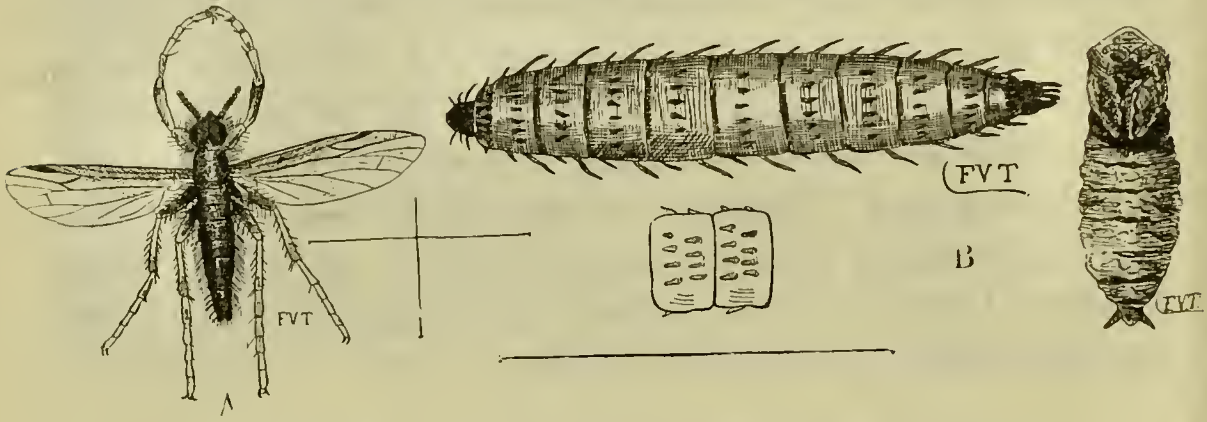

FIG. 122.—BIBIONIDÆ.
A, Adult *Bibio marci*; B, larva and pupa of *B. promonæ*.

Closely related to these are the Simulidæ or Sand-flies (fig. 123), which swarm in damp places. The females attack man, birds, and animals, drawing out the blood, and cause great irritation. The larvæ live in running water. Poultry is attacked by them in South Africa and also in America, where they are also known as Turkey gnats.

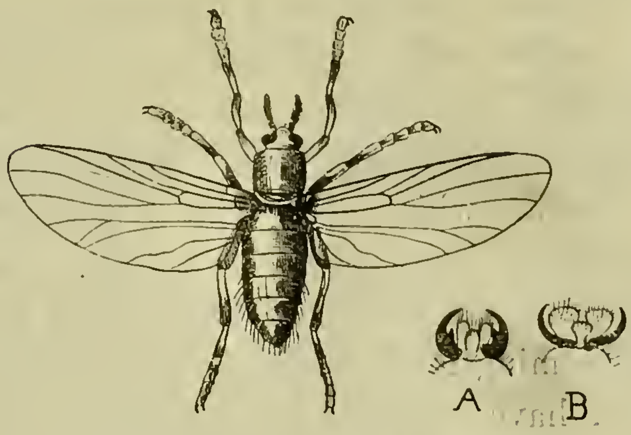

FIG. 123.—A SAND-FLY (*Simulium reptans*).
A, Ungues and pulvilli of Simulium; B, of Dilophus.

Another important family in the Nematocera are the

Tipulidæ or Crane-flies,

popularly called the Daddy-long-legs. Tipulidæ can at once be told by their long slender legs, which so readily fall off. The larvæ are called "Leather-jackets," and are root-feeders; some also live in decaying wood, and others in water. The pupæ are armed with bristles, and are always naked.

THE COMMON CRANE-FLY (TIPULA OLERACEA).

The female Crane-fly is brownish-grey, with a silvery hue, the wings having testaceous veins. The female is provided with a sharp conical ovipositor, the end of the male is blunt. The female, by means of this tube, lays black spindle-shaped eggs

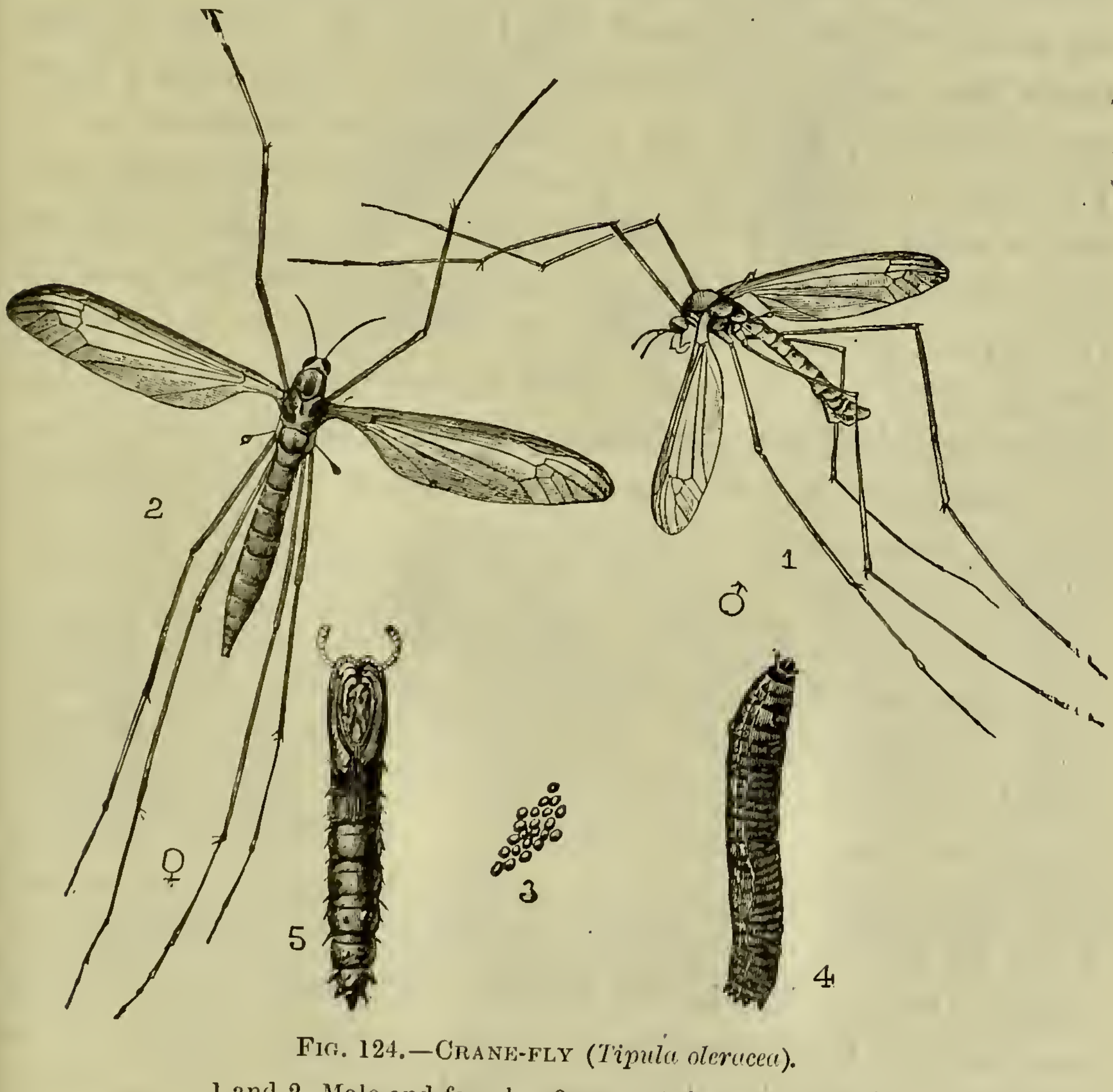

FIG. 124.—CRANE-FLY (*Tipula oleracea*).
1 and 2, Male and female; 3, ova; 4, larva; 5, pupa.

in the soil and on the grass near some plants—the greater the shelter the more they frequent it, hence we find these pests always most frequent in permanent pastures. They prefer damp spots to oviposit—in fact, most Tipulidæ frequent damp and swampy places, some larvæ living in water, even in brine pools. The black ova of the crane-fly soon hatch out into the larvæ. The adults appear twice a-year, one brood in the spring and early summer, the second in the autumn. The larvæ of the second brood live through the winter, and pupate in the summer. The majority hatch out in the autumn. The grubs are called "Leather-jackets" (fig. 124, 4), on account of their tough skin, which is brown and wrinkled. They have a blunt anal extremity, which has a few finger-like processes on it. The roots of practically all plants are attacked by them, and are so eaten away as to kill the plant. The pupæ are brown (fig. 124, 5), and provided with circles of spines; the head has two curved horns (palp cases). We find them in the ground, forcing their way up when ready to emerge by means of the spines, until half the pupal case projects out of the earth, when the shell splits and the fly emerges, soon to deposit fresh ova. Other species, as the Spotted Crane-fly (*Pachyrhina maculosa*, *Tipula paludosa*, *T. lateralis*), also cause loss.

Prevention and Remedies.—Gas-lime is very injurious to these grubs, and may be well employed on land when it is infested with "Leather-jackets." It is especially valuable put upon mould and leaf-heaps, where crane-flies lay their eggs abundantly, as a preventive of oviposition. The drainage of damp land often checks their presence. Brush-harrowing grass land when we see the flies about is advantageous, as it disturbs and crushes the eggs laid by the female. It is said that the larvæ come out on to the surface at night, and that rolling with a Cambridge ring-roller then does much good by crushing them. Vaporite I have found fatal to them. Birds are the great natural check of this pest, those that are beneficial being mentioned in another chapter.

WINTER-GNATS (TRICHOCERA HIEMALIS AND T. REGELATIONIS).

These delicate little Tipulidæ (fig. 125) are found dancing in the air in clouds in the winter months whenever the weather is warm. They are brownish-grey, with four brown stripes on the thorax, *T. hiemalis* having spotless wings, while *T. regelationis* has a dark spot on each wing at the cross veins. The larvæ live in rotting turnips; they are cylindrical, and taper to a point at the head end, about half an inch long, and dirty greyish-yellow in colour. They need no further comment, except that they may be generally looked upon as useful insects, helping the speedy decay of roots, &c., in the soil. Now and again, however, they have been known to attack sound plant tissue.

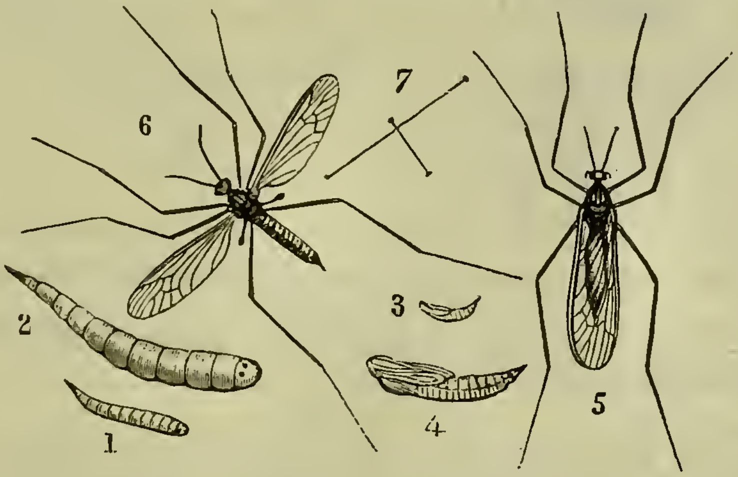

FIG. 125.—WINTER GNATS (*Trichocera*).
1, 2, Larva of *T. hiemalis*; 3, 4, pupa; 5, 6, imagines; 7, nat. size.

Amongst the Brachycera are some of great importance: only one group can be mentioned here, namely, the

Gad-flies or Tabanidæ.

Gad-flies are large flies with a flattened body and large broad head closely united to the thorax (fig. 127, c). They are all provided with a sharp piercing mouth (fig. 126, B), with which they suck the blood of man, horses, and cattle. The females are especially bloodthirsty; the males feed off the nectar of flowers. The larvæ (fig. 127, D) live in the ground, and are carnivorous in habits. They are also known under the names of Horse-flies, Breeze-flies, Seruts, and Brimps. There are several

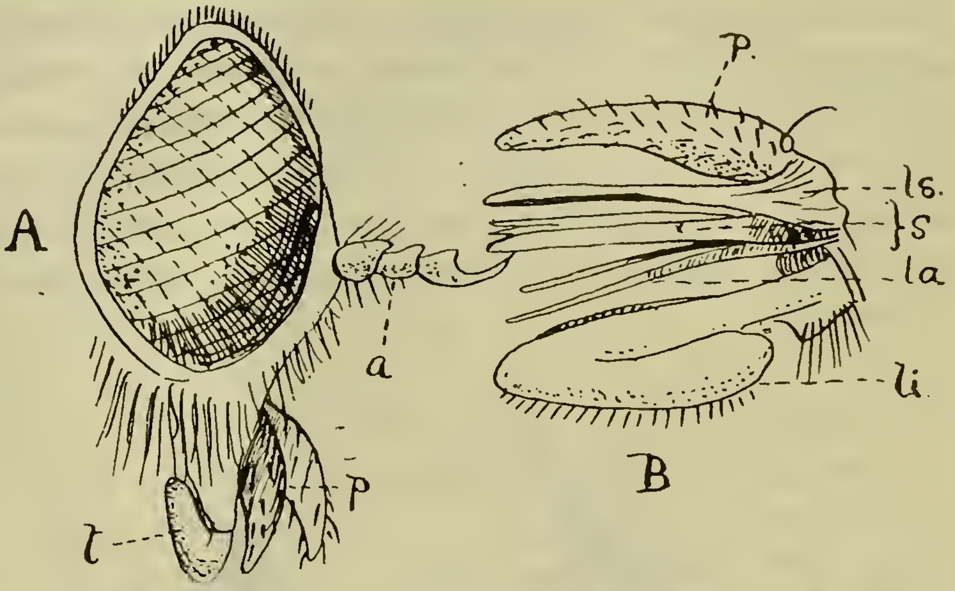

FIG. 126.—A, HEAD, AND B, PROBOSCIS OF TABANUS AUTUMNALIS. (After Delafond.)

a, Antenna; *p*, maxillary palp; *t*, proboscis; *s*, mandibles and maxillæ; *ls*, epipharynx; *la*, hypopharynx; *li*, labium.

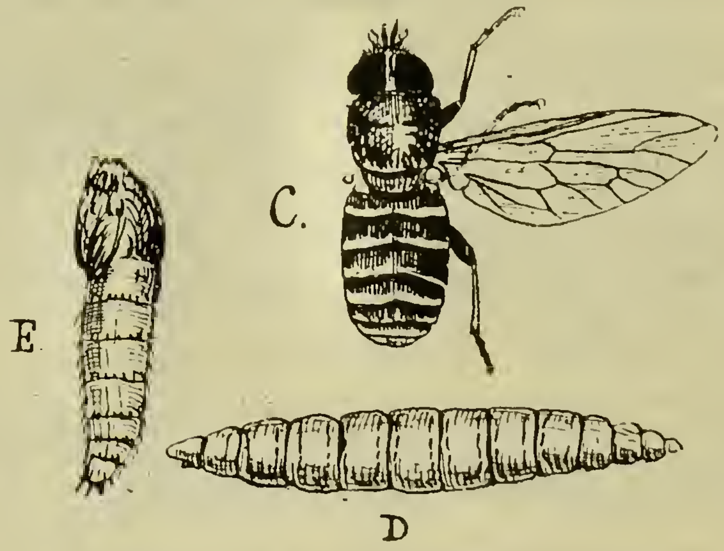

FIG. 127.—OX GAD-FLY (*Tabanus bovinus*).

C, Imago; D, larva; E, pupa.

species very common in Britain, notably *Hæmatopoda pluvialis*, *Chrysops cæcutiens*, *Tabanus bovinus*, and *T. autumnalis*. The first named is about half an inch long, whitish-grey, covered with pale dull hairs in the female, dark-grey in the male, wings mottled grey. The last two are especially troublesome in the New Forest, where they often tease horses severely. *T. bovinus* is frequently called the Ox Gad-fly; and some specimens reach more than an inch in length. In colour the male is dark-brown on the thorax, with five pale stripes, and pale yellowish hair; abdomen reddish-brown, with a black central line and tip, and with a pale spot in the middle of the posterior borders of the first to the fifth segments; the under-side of the abdomen orange colour. Eyes green. Wings yellowish-brown, veins yellowish in places. Legs dark-brown, except tibia, which are yellowish-red. The female has a curious coppery sheen over the green eyes, and the abdomen is flatter than in the male. An allied species, called *T. sudeticus*, is often mistaken for *T. bovinus*, but can at once be told by the eyes being brown, with a coppery sheen. *T. autumnalis* is also common: it is much smaller than the above, not much larger than five-sixths of an inch in length; its general appearance is grey, the thorax having five grey stripes; the greyish-brown abdomen has three rows of paler grey spots, the central one somewhat triangular.

Chrysops cæcutiens, or the Blinding Storm-fly, is about half an inch long; body with black and yellow markings. Eyes golden green, with brilliant purple spots and lines; wings black, with pale spaces in the male; transparent, banded with black in the female. It is a most vicious biter. As far as is known, they all feed in their larval state in the ground, and amongst wet decaying vegetation, in sand and soil generally. The larvæ are long, cylindrical grubs, yellowish-white in colour, with darker transverse bands; they are somewhat enlarged in the middle, and change to naked pupæ (fig. 127, E) in the soil. The adults come forth much in the same way as the crane-fly: these immobile pupæ can be told by the six spines on the last segment (in *Tabanus bovinus*). The Tabanidæ are chiefly abundant in well-wooded places, especially where water is near. The warmer the day the more ravenous and bloodthirsty the females become—at least that is my experience in Norway and Switzerland, where animals suffer much more from them than they do even in the New Forest. Tabanidæ can produce a loud buzzing noise, and frighten stock, just as do the Warble-flies, but the noise made by Tabanidæ is much sharper than the dull hum of the Œstridæ. In tropical countries they are great pests.

A plan to keep these pests off horses that I have seen employed in the Bernese Oberland is to dress the horses over with paraffin-oil and soap, rubbed with a sponge, and also with walnut juice. Miss Ormerod mentions soluble phrenyl as useful in one of her reports, but at present no substance is known that has any great effect in this direction.

Other flies belonging to the section *Cyclorrhapha* are divided into the *Proboscidea* and *Eproboscidea*. The Proboscidea contain the majority of flies, the following being some important economic groups :—

Hover-flies, or Syrphidæ.

The Syrphidæ are all moderate-sized flies, often brilliantly coloured, generally with banded bodies, yellow or white and black or brown being the predominating colours. They hover in the air like a hawk, suddenly darting off and again remaining hovering at a fresh spot. We only see them in the bright sunlight, and may notice them flying and hovering over plants, upon the nectar of which the adults feed. At other times we see them busy over colonies of Aphides, for here they deposit their eggs, their curious, almost repulsive-looking larvæ (fig. 128, 2 and 5) feeding upon plant-lice, which they devour with great rapidity. The larvæ are yellow, green, or red in colour, with a narrow anterior extremity, and are leech-like in movement. They pupate on the leaves where they have been feeding in sac-shaped cases or puparia (fig. 128, 3 and 6). The typical genus is *Syrphus*, of which there are a great number of species. Most have broadish flat abdomens, often almost transparent, with yellow and black bands, and extremely delicate pale-coloured legs. *S. ribesii* and *S. balteatus*, and the black and white *Catabomba pyrastri*, are perhaps our commonest species living on plant-lice. Some also feed on Scale insects (*Coccidæ*).

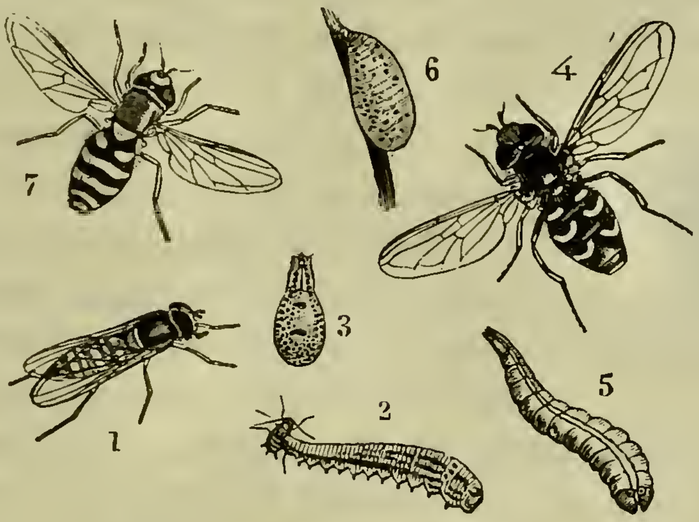

Fig. 128.—Hover-flies (*Syrphidæ*).

1, *Syrphus balteatus*; 2, larva devouring aphis; 3, pupa; 4, *Catabomba pyrastri*; 5, larva; 6, pupa; 7, *Syrphus ribesii*.

Other genera are parasitic (*Volucella*), living in the nests of Humble-bees (*V. bombylans*) and Wasps (*V. zonaria*), and mimic the colour and appearance of the insects they live amongst.

Warble-flies, or Œstridæ.

This family of flies is most obnoxious to our domestic and wild mammals, upon which they live as parasites during their larval period. Some also live upon man. The larvæ are called "bots," and live under the skin, in the head, and in the stomach and intestines of animals. The most injurious species are the Ox-warbles (*Hypoderma bovis* and *H. lineata*), the

Sheep Nasal-fly (*Œstrus ovis*), and the Horse-bots (*Gastrophilus equi*, *G. nasalis*, &c.), which we will deal with in the above-mentioned order.

OX-WARBLES OR BOT-FLY (HYPODERMA BOVIS AND H. LINEATA).

These two species, which are very similar in appearance, at one time caused serious loss amongst beasts: the annual amount, according to Miss Ormerod, was something like £7,000,000. But, thanks to her great energies, this serious malady has been checked, although it still does a great amount of harm. The Ox-Warble fly (fig. 129) is like a small hairy humble-bee in appearance, gaily coloured with thick hair of yellow, black, and red bands on the abdomen, and with yellow and black marks on the thorax. The head of these Œstridæ is large, but the mouth is very rudimentary. The Warble-fly itself cannot bite like the Gad-fly; it pursues the cattle to lay its eggs. The Ox-Warble fly appears in the summer from June to August and September, delighting in hot still days, when we can hear its low dull "burr" in the air. It is quite a mistake to fancy the Warble-flies make no noise. I have frequently heard the low hum produced by *Œstrus ovis*, and taken the insect on the wing. The ox-pest lays its eggs on the hair of the legs and flanks, and it is these eggs that hatch into the so-called "Ox-bots" (fig. 130). At first the young larvæ are white and thread-like. They are sometimes also red when examined in this condition. For some little time they show no signs of their presence externally, but a few months later a small swelling appears over the "bot." After the larva has moulted a second time

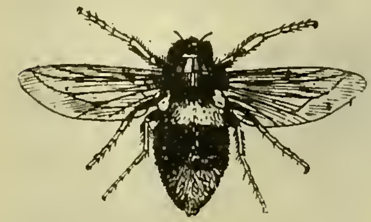

FIG. 129.—OX-WARBLE FLY (*Hypoderma bovis*).

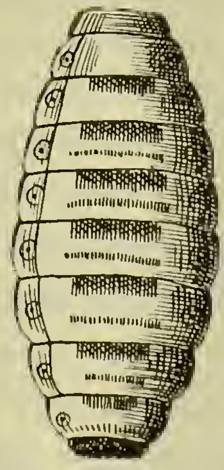

FIG. 130.—OX-BOT. (Enlarged $\frac{1}{3}$).

it becomes banded with prickles, which cause irritation and inflammation of the immediate surrounding parts, and thus the swelling or "warble" is produced. We notice these outward signs of attack coming about January. The inflammation set up by the bot produces matter, which eventually causes the warble to burst at the top, a small round orifice appearing. The "bot" lies beneath this, in a cell formed in the hypodermal tissues, and when full grown squeezes its way out and falls to the ground, where, wriggling under some tuft of grass or stone, it pupates in its old larval skin. *H. lineata* is much like *H. bovis*, but somewhat smaller.

The small maggots on hatching enter the skin and wander about until they eventually reach the back or flank. At one time they were supposed to be licked up by the cattle and enter *viâ* the mouth, but Carpenter has recently shown that muzzled calves become parasitised.

Prevention and Treatment.—Smearing the back and loins of beasts with some greasy substance, such as cart-grease and paraffin, was recommended. As the flies lay their eggs on the legs it is not surprising that this did little good. Smearing the legs and flanks, however, is likely to be beneficial. As Warble-flies are very susceptible to changes of temperature, and will not enter shade or pass over water, giving the cattle shelter either of trees or rough hovels in the meadows, or turning them where they can run to water for protection, is advisable. Remedial measures consist of destroying or extracting the larva from the warble. Mercurial ointment is one remedy; a small piece rubbed into the warble when it has just opened will soon destroy the grub, and allow the wound to heal up. Not only does the ointment kill the larva by blocking up the air-pores or spiracles, but it destroys the grub in the cell; but it should not be used in great quantities. Cart-grease and M'Dougall's smear have similar effects, but are not nearly so certain in results. There is nothing like the old plan of squeezing out the maggot and killing it at once, before the warble has become too old.

The Sheep Nasal-fly (Œstrus ovis).

Sheep are often seen shaking their heads and stamping on the ground; at other times running about with their noses close to the grass. These are symptoms that *Œstrus ovis* is about, ready to deposit its eggs or young. The fly appears in the summer; it is a dull-coloured insect, which we often see in sheep districts at rest at dusk, and in cold weather on the sheep-pens and hovels near the sheep. The female may deposit living young or ova on the sheep's nose, and the maggots crawl up the mucous membrane and some enter the sinus of the head. The majority live in the nasal passages, and when mature are thrown out on to the grass during one of the violent fits of sneezing that they often occasion by the irritation of the mucous membrane. The puparia are found, like those of the ox-bot, beneath some shelter on the ground. Many of the bots in the sinus cannot escape, and thus die. On one occasion the author extracted from the cerebral hemisphere a larva of the fly, it probably having entered through the cribriform plate of the ethmoid bone; in another case one was found in the trachea. Sheep when suffering from this pest shake their heads and wander restlessly about, and present some of the symptoms of Sturdy. The disease for this reason is called False-Gid; it can be told from true Gid (*Cœnurus cerebralis*) by the copious mucous discharge from the nostrils, and the absence of that rotatory movement seen in sheep suffering from Sturdy.

Prevention and Treatment consist in warding off the fly attack by either placing some substance on the sheep's nose every now and then, such as strong smelling oils, removing them for a year from pastures that are known to be contaminated with the puparia, and placing salt in tarred boxes, so that the sheep get the creosote on their noses whilst licking the salt.

THE HORSE-BOT (GASTROPHILUS EQUI).

The Horse-bot Fly (fig. 131) is brownish-grey in colour, has mottled brown wings, and appears much about the same time as those just mentioned. The eggs (A) are quite large objects, laid on the hair of the horse at the knees and shoulders. It seems that at the same time as the female lays her eggs she places some irritating poison on the skin, which causes the horse to lick the spot. The warm breath hatches the larva, which attaches itself to the tongue and crawls down the animal's throat, taking up its position in the left or cardiac portion of the stomach (the white half). The bots congregate here, and hold on to the mucous membrane by their two-hooked mandibles until mature. They are pinkish-white barrel-shaped larvæ, with circles of spines (fig. 132, A). We see them sometimes sticking round the horse's anus. From six to nine months are passed in the horse's stomach; when maturity is reached they pass out *viâ* the intestines to the exterior in the fæces, pupating in a puparium case on the ground, like *H. bovis* and *Œ. ovis*.

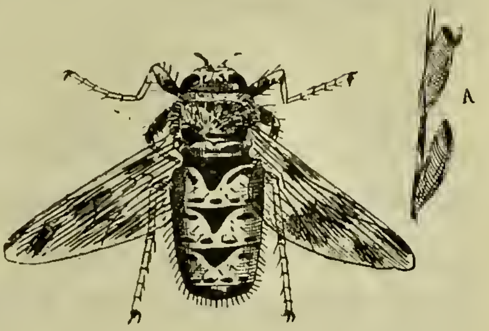

FIG. 131.—HORSE-BOT FLY (*Gastrophilus equi*) (slightly enlarged). A, Ova, enlarged.

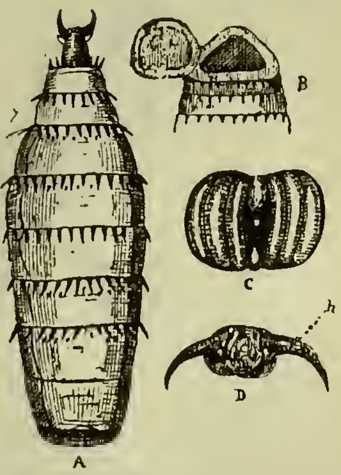

FIG. 132.—LARVA OF HORSE-BOT FLY.

A, Horse-bot; B, end of puparium; C, spiracles at anal end of bot; D, hooked mandibles.

Prevention and Treatment. — Well-groomed horses seldom suffer from this pest, because the eggs are detached by the "curry-comb." Farm-horses in districts where *G. equi* is abundant should have shelter from the sun during the hot part of the day; and those in use should have their knees and shoulders dressed with salt-and-water and some deodorant, to deter the fly from ovipositing. Salt is said to be good, but how it works is unaccountable. Tartar emetic in two-drachm doses every day for ten days *is said* to clear the "bots" out of the stomach. Other species, such as *G. nasalis* and *G. hæmorrhoidalis*, live in a similar way.

Several other "bot-flies" occur in Britain (*Hypoderma diana* and *Cephenomyia rufibarbis*, both on deer). Man is attacked by *Hypoderma linearis* and *H. bovis* in Europe and America (so-called Creeping Disease), and by the *Dermatobia cyaniventris*, or the Torcel Fly, in S. America, and others.

Root-eating Flies (Anthomyidæ).

The Anthomyidæ include a great number of flies which are all more or less dull in colour, and covered with many bristles and hairs. Their larvæ are white footless grubs, which taper to a point towards the head end, and are blunt at the posterior end. Several are very injurious to crops. No full description of the adults will be given here, as they are all much alike: only specialists are able to identify them with any certainty.

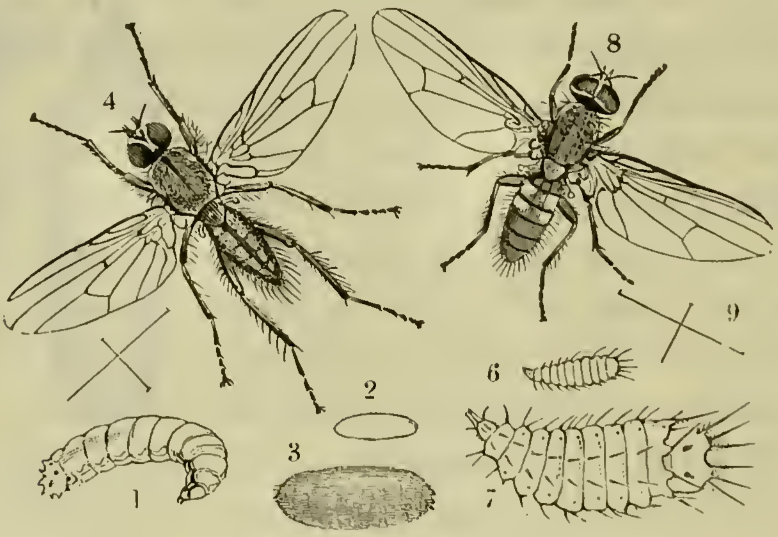

Fig. 133.—Root-eating Flies.

1, Larva of *Phorbia brassicæ;* 2 and 3, puparium of *P. brassicæ;* 4 and 5, *A. radicum;* 6 and 7, larvæ of *Homalomyia;* 8 and 9, *Homalomyia* sp. (?)

The larvæ live in the roots of plants and set up decay. The most important are the following: the Onion Fly (*Phorbia cepetorum*); the Cabbage-root Flies (*P. brassicæ*, *A. radicum*, and *A. floralis*); and the Wheat-bulb Fly (*Hylemyia coarctata*).

THE ONION FLY (PHORBIA CEPETORUM).

One of the most serious difficulties the onion-grower has to contend with is the Onion Fly, whose larvæ cause the maggot in onions and their speedy decay. The onion fly is an ashy-grey fly with black bristles and hairs, and with three black stripes on the thorax; the abdomen has a row of large black spots along it; the face is silvery-white, and the antennæ are black; the female has a yellow face, and is generally more ochreous in colour. The onion fly appears in April and May, and has several broods during the year. The female lays her ova near the young onions, and later on in the year on the onion itself. The young maggots at once eat the young onion below ground, and later feed inside until they are quite hollowed out. Some plants are killed rapidly, but large onions remain some time in a diseased state. When young onions are attacked the maggots pass rapidly along the row. When an older onion is destroyed, if the maggots are not mature they

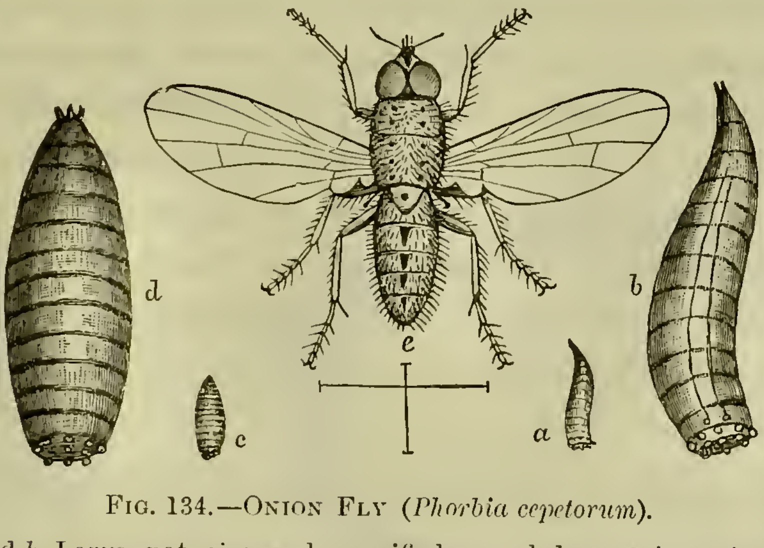

FIG. 134.—ONION FLY (*Phorbia cepetorum*).
a and *b*, Larva, nat. size, and magnified; *c* and *d*, puparia; *e*, imago.

leave it and also pass to the next onion through the ground. Pupation takes place in the ground, and in the decaying onions, —the pupa is in a chestnut-brown puparium case, as in all the Proboscidea. At the end of the year the larvæ of the last brood all pupate, and pass the winter as puparia in the ground, some few being harvested with the onions. We frequently turn up the chestnut-brown puparia in the winter, when digging the beds over. The presence of onion fly can at once be told by the leaves becoming flabby and turning yellow. When we try to pull up the onion the leaves come off in the hands, the plant being rotten. This rot is set up primarily by the onion maggot, secondarily by fungi, bacteria, and damp attacking the weakened bulb.

Prevention and Remedies.—Applications of soot over the young plants to ward off attack. Pulling up diseased plants and destroying them with the enclosed larvæ. Watering around the young onions with paraffin emulsion. Early sowing of seed, so as to get the plant well up before the fly comes. Lightly earthing up the rows, so as to prevent the fly from depositing her eggs : the larvæ cannot crawl far when young, and thus die from want of food. Sprinkle common washing-soda along the sides of the young plants, or hoe in vaporite.

Cabbage-root Flies (Phorbia brassicæ, &c.)

Cabbages and turnips are often attacked by the larvæ of the above,—small white grubs, cylindrical in form, tapering to a point towards the head end like the onion maggot. These grubs may produce swellings or galls on the roots of cabbage, and tunnel in the lower parts of the stalk ; these galled parts decay in wet weather, and not only stop the plants from growing but often kill them outright. They go on appearing all the year, there being a number of successive broods. When the larva is full grown it leaves the plant and turns to a brown puparium in the earth, speckled with dark-brown. We find maggots in the very early spring as well as puparia. The Cabbage Fly (*P. brassicæ*) is ashy-grey, and hatches from the puparium in about three weeks: the male has a black stripe down the abdomen and three on the thorax. The fly galls on turnips must not be confused with those of the Turnip-Gall Weevil (*Ceutorhynchus sulcicollis*). The Radish Fly (*A. floralis*) has a spiny maggot; *A. radicum* (fig. 133, 4), a yellowish grub with two black points at the end of the tail.

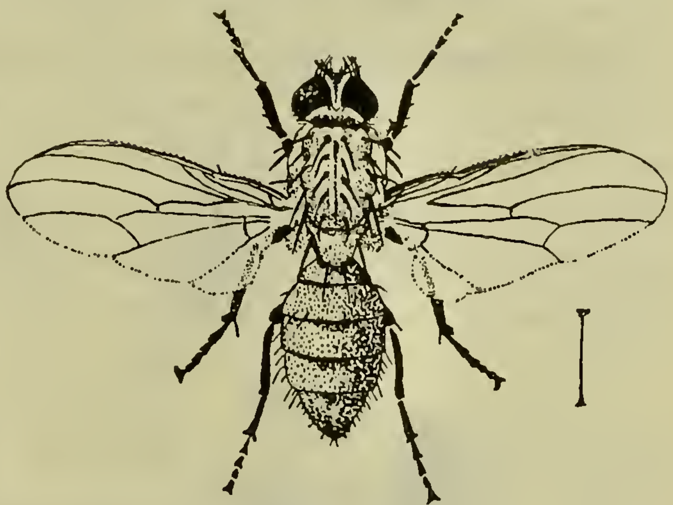

Fig. 135.—The Cabbage-root Fly (*Phorbia brassicæ*).

Prevention and Treatment.—Little can be done when the grubs are once installed in a plant. Where cabbages are grown year after year on the same land, the soil is sure to become contaminated unless cleaned annually; for this gas-lime, or, better, vaporite, is recommended. Dibbling in the plants with a little soot and lime is a good deterrent; and broadcasting the same over young plants not only keeps off these flies but slugs as well. All the diseased cabbage stalks and roots ought to be burnt, instead of being put up in heaps to rot, when many of the grubs will escape and pupate. Card discs are sometimes used, as shown in fig. 136, to prevent egg-laying.

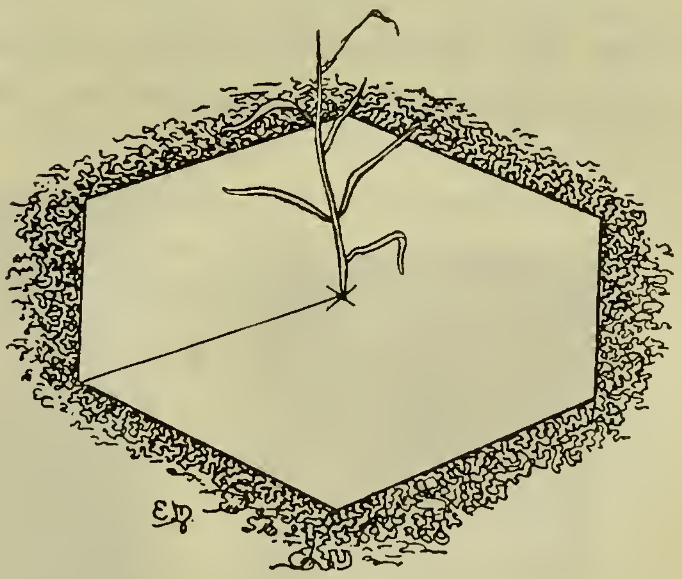

Fig. 136.—Card disc to prevent Egg-laying of Cabbage Fly.

Wheat-bulb Fly (Hylemyia coarctata).

The Wheat-bulb Fly is chiefly harmful in the Fen districts to wheat, but occurs in many other parts. It is said to be most destructive on land fallowed in the previous summer, and where the crop has been so thin as to expose the land (Ormerod). The Wheat-bulb Fly lays her eggs in the young wheat, the larva living in the centre of the plant. The grub is white in colour, and can be told by the curious processes at the tail end. These larvæ are found in April destroying the young plant: they lie lengthways up the plant, and reach from one-fourth to one-third of an inch in length. The puparia are found in May, from which the fly comes out in July. The imago is very like the Onion Fly: the thorax is grey, with pale sides and with stripes above; abdomen ashy-grey with an indistinct dorsal stripe; legs black with pale tibiæ; abdomen hairy. The female is entirely ashy-grey, posterior and middle femora and tibiæ pale. The attack often follows on fallow land, and it has been noticed to occur after the land has been dressed with pond mud. Probably couch-grass harbours this fly. Where it is prevalent, as in some Fen districts, the seed should be sown thickly, and the attacked crop given a good dressing of artificial manure.

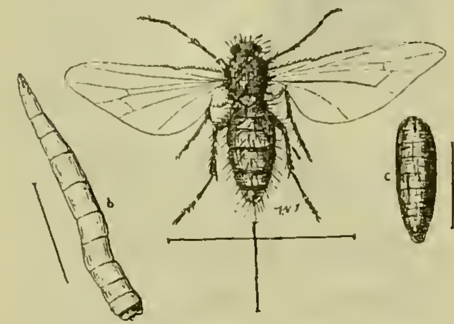

Fig. 137.—Wheat-bulb Fly. *b*, Larva; *c*, puparium.

The Mangold Fly (Pegomyia betæ).

Amongst the pests common to Mangolds and Beets this fly is perhaps the most important. The fly is an ashy-grey with black bristles, very similar to the Onion Fly in general appearance. It occurs as early as May, when it deposits elongate white eggs (fig. 139, a) on the under-surface of the mangold leaves, even on the cotyledons: these ova are usually placed in groups of two, three, or four, close together, each egg being sculptured hexagonally. In a week or ten days they hatch into small white maggots, which burrow into the soft mesophyll layers of the leaf: there these footless grubs live for four weeks, forming first a small pale-green patch, which gradually grows into a white and then brown blister. When held up to the light the maggots can be seen within. On reaching maturity they mostly fall out to the ground, where, as in all this group of flies, the skin of the larva hardens and forms a brown puparium, as soon as the larva has pushed its way an inch or two under the soil. In

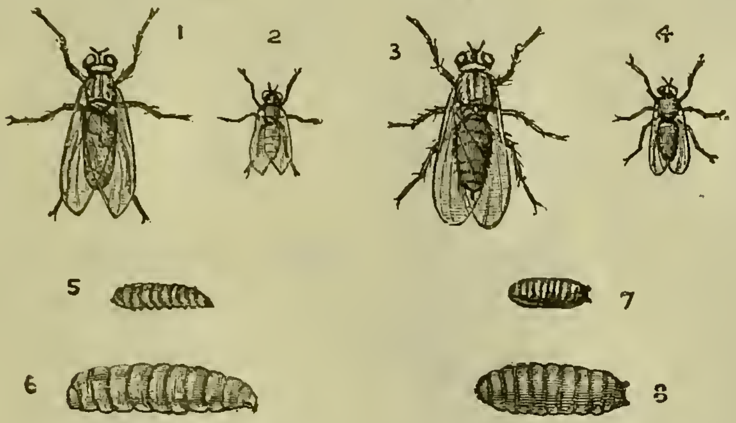

FIG. 138.—MANGOLD FLY (*Pegomyia betæ*).

1 and 2, Male, nat. size, and mag. ; 3 and 4, female, nat. size, and mag. ; 5 and 6, larva, nat. size, and mag. ; 7 and 8, puparium, nat. size, and mag.

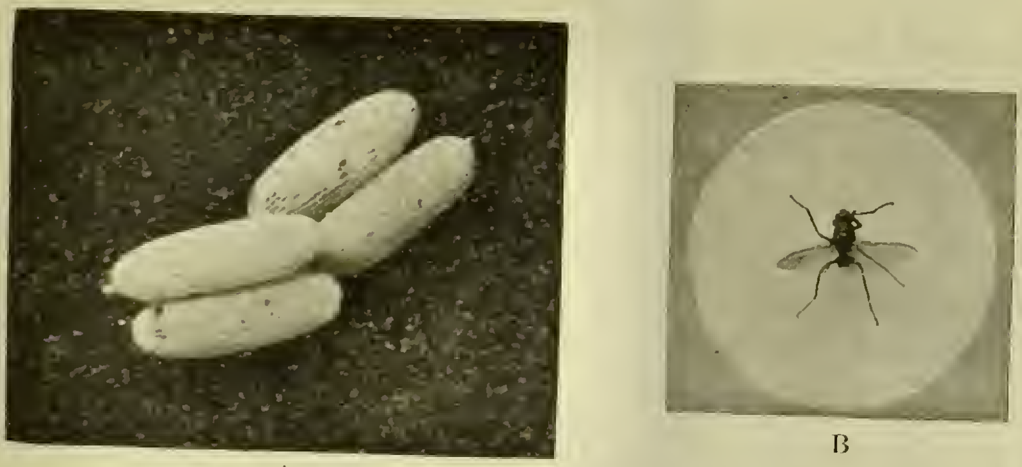
A
B

FIG. 139.—A, OVA OF MANGOLD FLY (*Pegomyia betæ*), and B, adult.

the summer the fly comes forth in about two weeks. There are many generations in the year: the last all turn to puparia, and remain as such in the soil and in the decaying leaves all the winter. The attack is sometimes very serious, especially when the ova are laid on very young plants after they have got into rough leaf. If the brood comes when only the cotyledons show, then the maggots die, as the seed-leaves shrivel up. Sugar Beet is also attacked.

Prevention and Remedies.—There are three points worth mentioning: first, the destruction of winter puparia by the usual methods of deep ploughing; secondly, the application of some stimulating manures to the attacked crop, especially nitrate of soda; and thirdly, spraying, where a "strawsoniser" can be used, with paraffin emulsion. There being many generations, we should try and kill the first.

FAMILY **CHLOROPIDÆ.**

THE GOUT FLY (CHLOROPS TÆNIOPUS).

In poor land barley may often be seen stunted and swollen, and unable to burst its way out of the ear. This peculiar appearance is called "Gout," and frequently causes a serious deficit in the crop. This swollen diseased state of the plant is produced by a small fly belonging to the *Chloropidæ*, called the Ribbon-footed Corn Fly or Gout Fly (*Chlorops tæniopus*). It is a small fly about one-eighth of an inch long, thickly built; the thorax is yellow, and has three dark blackish-green stripes on it; the abdomen is greenish-brown with dark bands across. The female lays her eggs separately, one larva sufficing to produce this gouty appearance. She deposits them on the barley plant just when the ear is still in the sheathing leaves, either within the leaves or so that the young larvæ can speedily enter. The larvæ first devour some of the developing grain on one side, and then commence to tunnel down the stem to the first node,

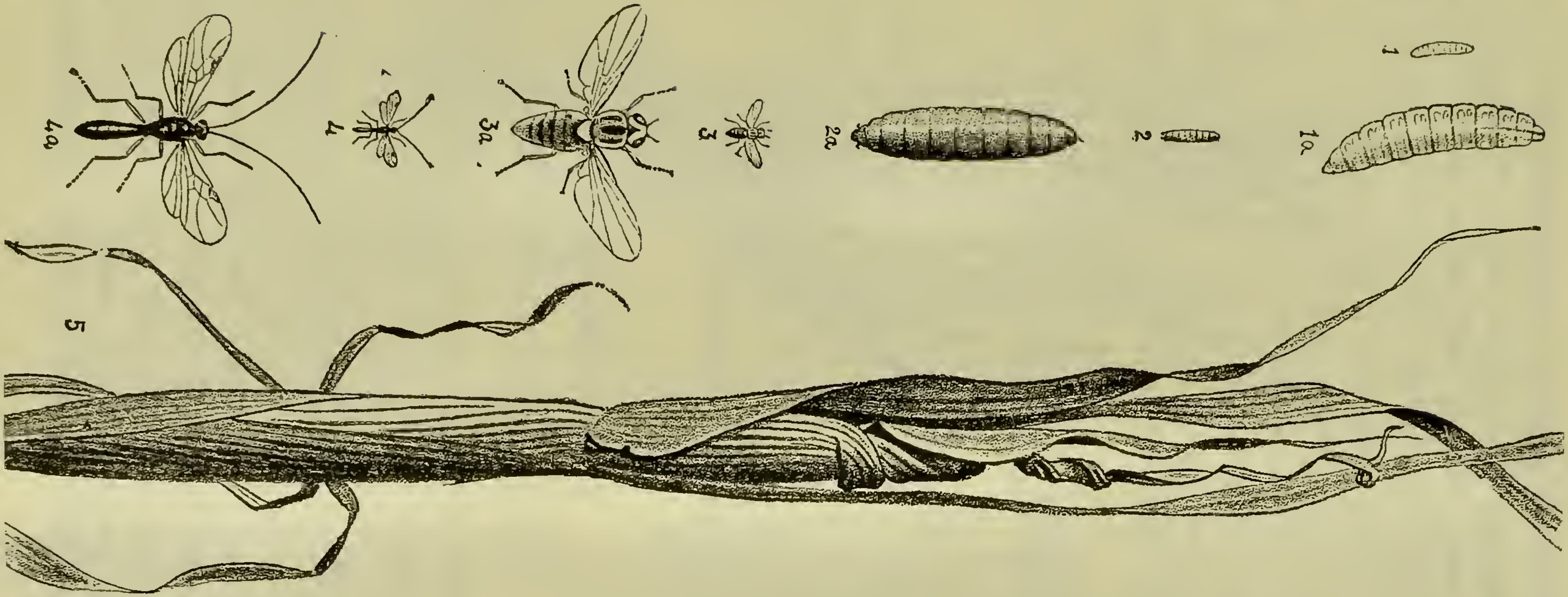

FIG. 140.—GOUT FLY (*Chlorops tæniopus*).

1 and 1*a*, Larva, nat. size, and mag.; 2 and 2*a*, puparium, nat. size, and mag.; 3 and 3*a*, imago, nat. size, and mag.; 4 and 4*a*, *Cœlinius niger*, nat. size, and mag.; 5, diseased barley.

forming a small black passage in which the grub turns to a yellowish-brown puparium. From this there appears a second brood of flies, which deposit their ova on various wild grasses, and pass the winter in them. That is the reason why we always find this gout attack most marked round the borders of the fields and along the grassy headlands, and any rough grassy ditch running across the land. Sometimes the plant is sufficiently strong to come out of its sheathing leaves, and then we can detect its presence by some of the grains having gone, and by the black tunnel extending from the ear down to the first node.

An Ichneumon (*Cœlinius niger*) attacks the Gout Fly larva (fig. 140, 4 and 4*a*), also a small *Pteromalus* described by Curtis as *P. micans*.

Prevention and Remedies.—Early sowing is one of the best preventives, and the application of stimulating dressings to the crop so as to carry it along. Mowing down the rough grasses round the headlands, &c., in the winter and burning them will kill numbers, for they are found breeding in such places in the winter and also hibernating as adults there.

FAMILY **OSCINIDÆ**.

THE FRIT FLY (OSCINIS FRIT).

Oats are often seriously injured past recovery by a small larva in the centre of the plant. The disease is spoken of as "Botley" or "Potley" Oats. This is the larva of a small black fly, the Frit Fly, which belongs to the family *Oscinidæ*. We notice this pest by the young crop withering away in June. Generally speaking, the Frit Fly damage can be repaired if taken in time. Barley is attacked on the Continent as well as oats, but in Britain only the latter suffers. We can early detect its presence by the central leaves here and there turning brown or reddish-yellow, and on examination a small maggot will be found in the shoot. The Frit Fly is a small, black, shiny dipteron about one-eighth of an inch in length. The eggs are laid by the females of the first brood upon the young oats, and the maggots coming from these live in the heart of the young plant. The larvæ are cylindrical white grubs, one-eighth of an inch long when mature, and have a pair of branched spiracles projecting on each side near the head, and two other tuberculate spiracles on the tail. They pupate in the outer dying leaves, as small reddish-brown bodies, from

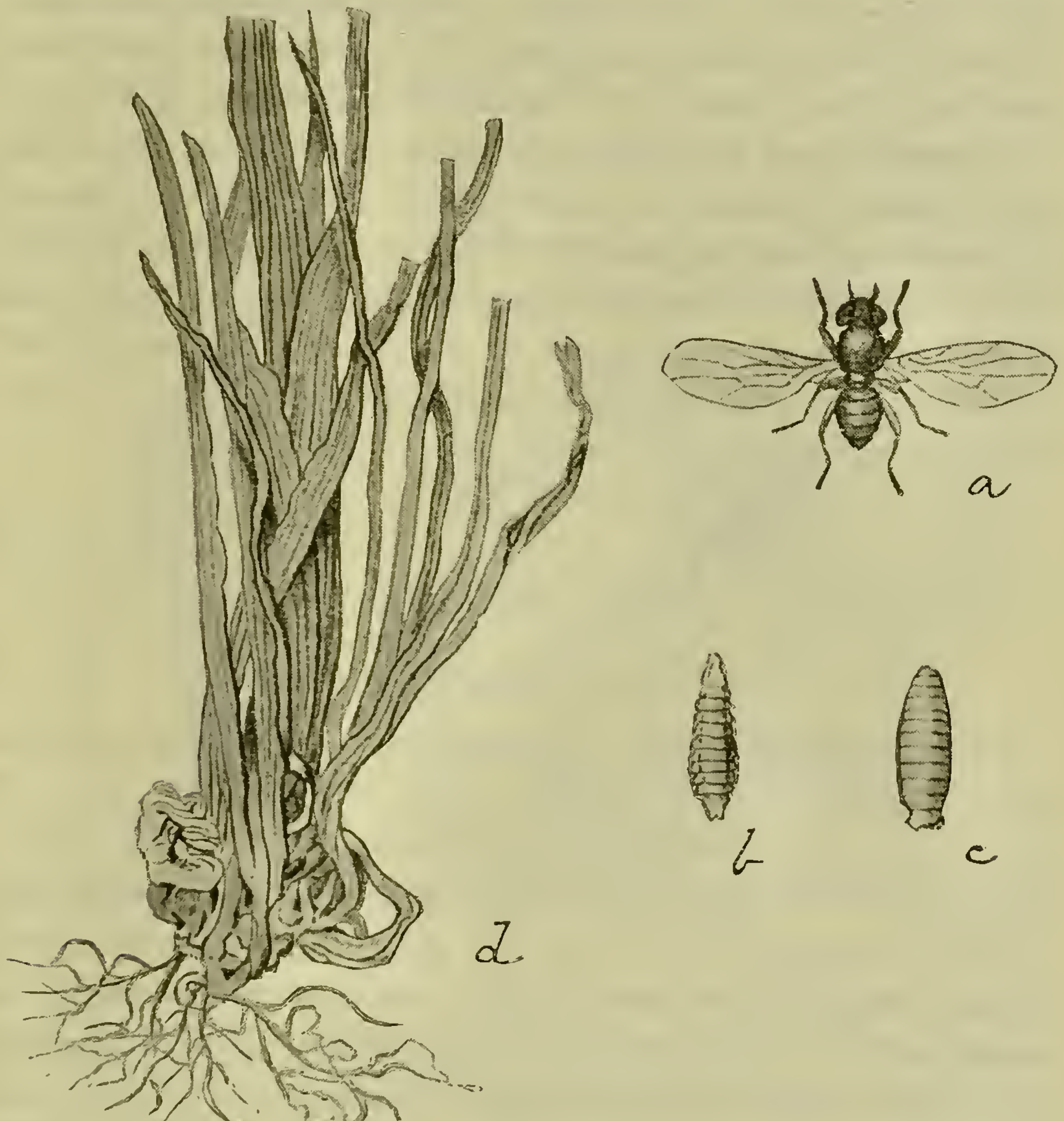

Fig. 141.—The Frit Fly (*Oscinis frit*).
a, Adult; *b*, larva; *c*, puparium (all enlarged); *d*, young infested plant.

which the flies come from the end of June to the end of July. The second brood after hatching out sometimes attacks the corn, laying its eggs in the ear. One instance of this attack in barley has come to my notice in Britain. The later hatched ones live as larvæ in wild grasses, and having matured are ready to attack the oats in the spring. This disease is often found combined with an attack of Tulip Root (*Tylenchus*), p. 80.

Prevention and Remedies.—In some cases where the whole crop is badly attacked it is advisable to plough it up. Should this be done, it is important to plough in as deeply as possible, so as to effectually bury the insects, which speedily hatch out. If on the first signs of attack we use stimulating manures, we can still get a good crop, the healthy plants tillering out over the space left by the dying ones.

FAMILY **PSILIDÆ**.

THE CARROT FLY (PSILA ROSÆ).

Every one who takes an interest in the garden knows the disease called "rust" in carrots. Rust is due to the larvæ of one of the flies belonging to the family *Psilidæ*. The Carrot Fly (*Psila rosæ*) (fig. 142, 7 and 8) is a small fly less than half an inch in expanse of wing, of a shiny metallic green colour, with a large yellow head, black eyes, and yellow legs; the wings are iridescent, and the veins yellow. The flies appear about the time the young carrots are up, and lay their eggs close down upon the plants; the young larvæ coming from them are long pale yellowish maggots pointed at the head end. They are white when quite young, and at once eat their way into the carrot, where they tunnel about at first under the rind, then internally, and cause rusty patches to appear over their abode. The tip of the carrot is often first attacked. On pulling up a carrot showing outward signs of this attack, one may find several of these larvæ half out of the carrot (fig. 142, 3 and 4); but they do not come right out until they are ready to pupate, when they leave the tunnels and metamorphose in the ground. The brown sausage-shaped puparia (5 and 6) are long and cylindrical and somewhat wrinkled; from the pupa inside the fly hatches in about three weeks. There are several generations in the year—at least three according to my observations. The grubs may be found at all times, from May until the carrots are lifted. When "rusted" the carrot leaves turn prematurely yellow and red, and thus clearly indicate the presence of *P. rosæ*. These flies are undoubtedly attracted to the young carrots by their smell, as we find in Onion Fly, Turnip Flea, &c. It is especially after thinning that the carrots get blighted, and this for two reasons—first, we bruise the plants in thinning them, and thus release the smell; and secondly, by loosening the earth around we expose the carrots more readily to the fly. We should remember in all these pests that the eggs must be laid on or very near the plant, as the young larvæ cannot travel far.

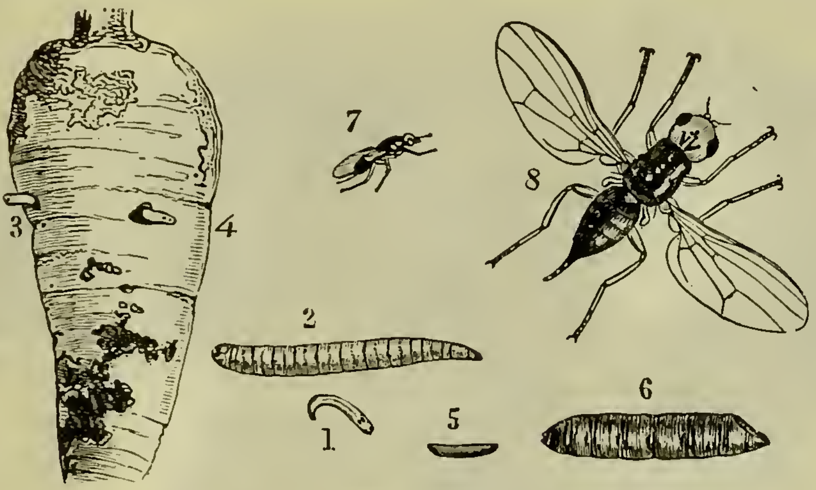

FIG. 142.—CARROT FLY (*Psila rosæ*).

1 and 2, Larva, nat. size, and mag.; 4, rusty carrot; 3, enclosed larva; 5 and 6, puparium, nat. size, and mag.; 7 and 8, imago, nat. size, and mag.

Prevention and Remedies.—When thinning is necessary, we should broadcast over the plants sand or ash in which a small quantity of paraffin has been mixed, about a pint to a bushel of sand. This destroys the smell, fills in the crevices, and stops oviposition. If possible, it is advisable to sow the seed sufficiently thinly, so as not to necessitate thinning until late in the season. Purifying the beds in winter with gas-lime or vaporite is also valuable as a preventive of future attack.

Family **TRYPETIDÆ**.

The Celery Fly (Acidia heraclei).

The blistered leaves we see so often on celery and parsnips are caused by a small fly which belongs to the family *Trypetidæ*—flies which have mottled or ornamented wings. On examining a blister, we find, within, one or more white larvæ feeding on the soft mesophyll layer between the upper and

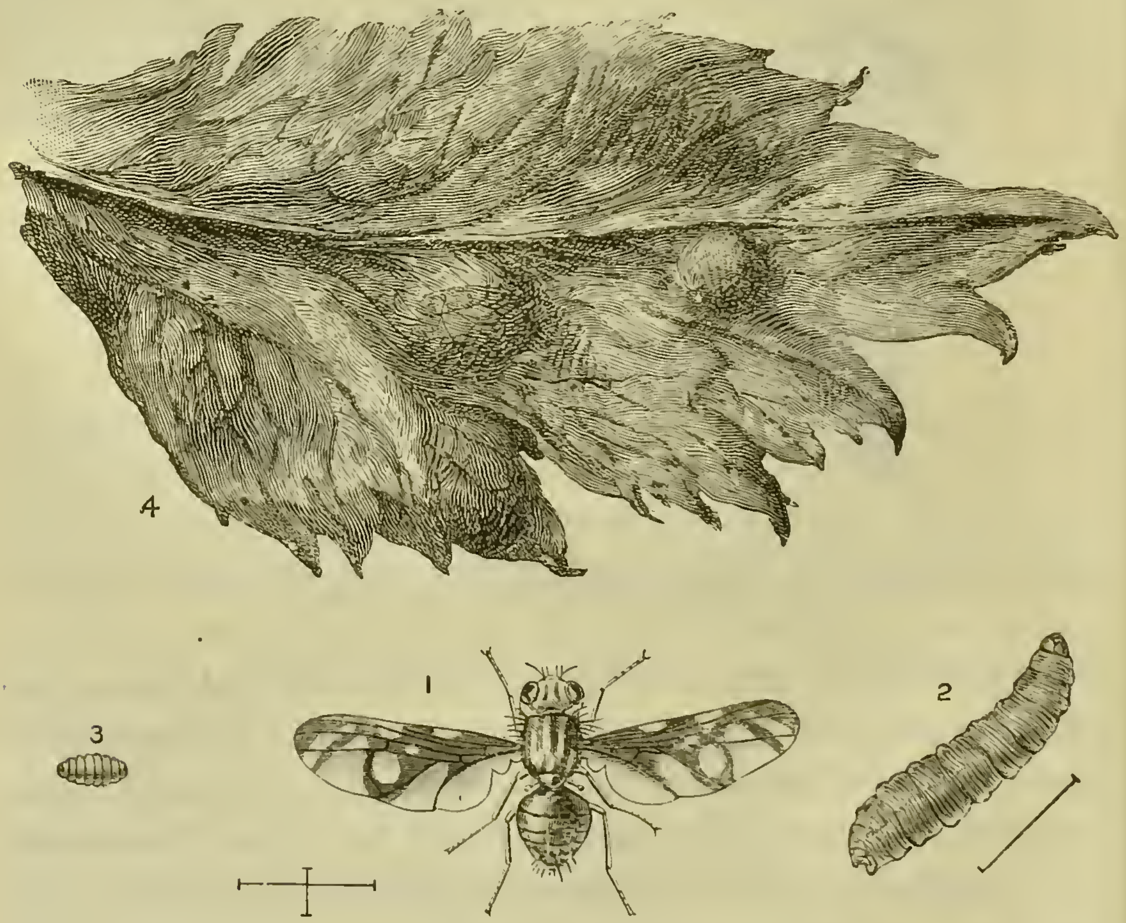

Fig. 143.—Celery Fly (*Acidia heraclei*).

1, Imago; 2, larva, mag.; 3, pupa, nat. size; 4, leaf mined by larvæ.

lower epidermis, thus clearing out the green mass of the leaf and leaving behind a pale blistered patch. The grubs are the larvæ of the so-called Celery Fly, which is a small pale-brown fly, with wings mottled with dark brown, and with green eyes. It lays its eggs on the celery leaf, and the young larvæ at once burrow into the interior. They are found hovering over the celery plants as early as April, but the majority come out in June. The pale blisters become brown, and inside these diseased spots the white larva may turn to a yellowish puparium. There are several generations in the year. Some puparia are found in the earth, especially during the winter months. The larvæ go on working in mild winters as long as the celery is in the ground. They must not be confused with the Celery-stem Maggot, *Piophila apii*, although the *A. heraclei* larva has been found in the celery stalks.

Prevention and Remedies.—As we find the puparia in the leaves and in the ground, we must try to get rid of them in both places, and so effectually stop their increase. The leaves should be burnt and the beds dressed with gas-lime in the winter, as after all attacks of garden pests. Spraying the young celery plants with tobacco wash, every now and then in the summer, keeps off the fly. The old plan of pinching the leaves that are blighted cannot be advised, as the leaves get ruptured and the sap pours out, and thus more damage is done than by the larva.

Young celery before being set out should be kept in bright weather covered with muslin, so as to stop the flies from laying their eggs.

FAMILY **MUSCIDÆ.**

THE HOUSE-FLY (MUSCA DOMESTICA).

Although the House-fly is not an agricultural pest, yet it is sufficiently obnoxious to allow a few lines to be devoted to it. The House-fly (*M. domestica*) belongs to the family Muscidæ, a family that contains the Blue-bottle Flies (*Calliphora*) and Green-bottle Flies (*Lucilia*), as well as the dreaded Tsetse-flies of Africa (*Glossinæ*).

This household pest is found in all parts of the world near habitations. The adult house-fly is ashy-grey, more or less ochreous at the sides in the male, ashy-grey in the female; head black between the dull-reddish eyes, which are surrounded by a shiny white circle, and the face is the same colour; the grey thorax has four black lines upon it, and the legs are rather slender and black. The life-history of this species may briefly be summed up as follows: The flies lay their eggs in putrid and decaying substances, human fæces, spent hops, &c., but especially in horse-manure; they deposit their eggs in batches, each fly producing from one hundred to one hundred and fifty

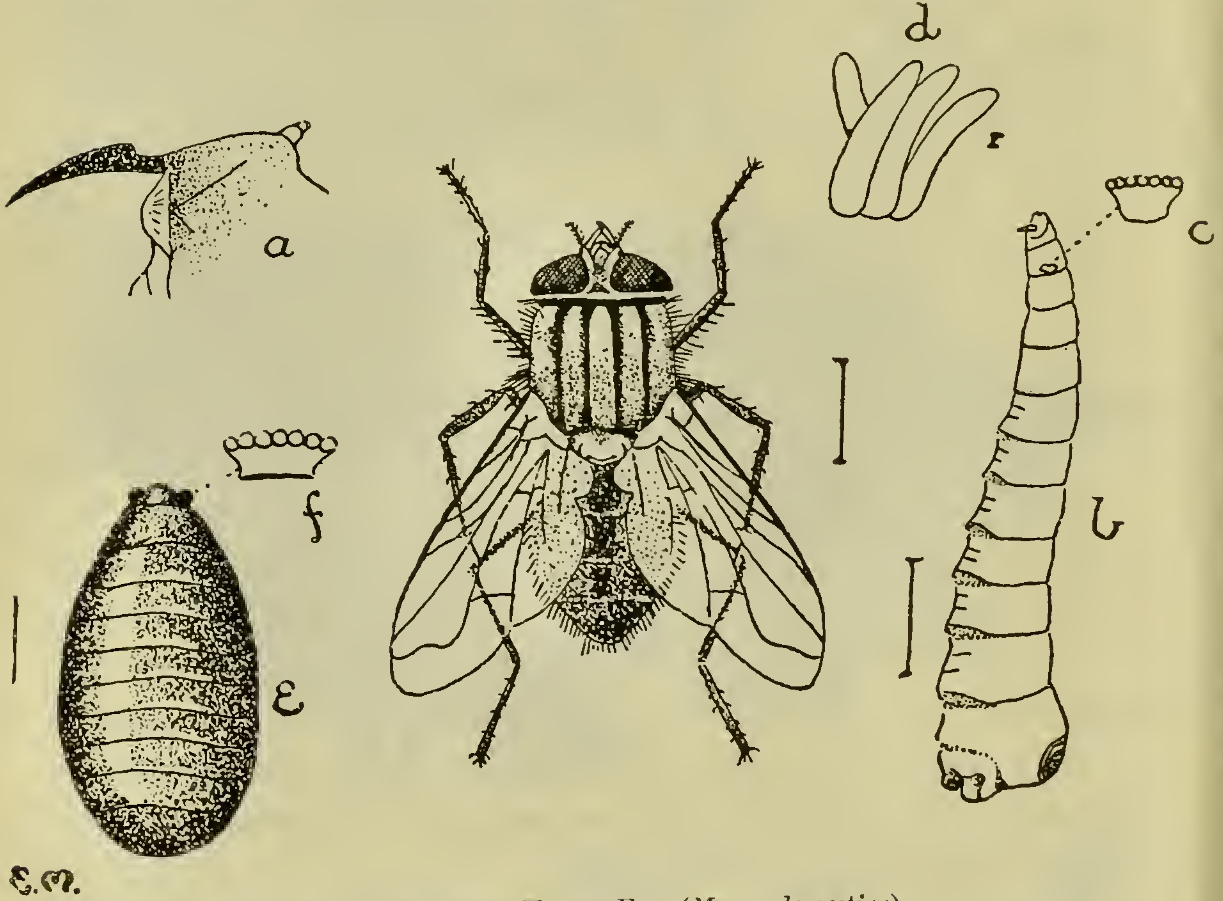

FIG. 144.—THE HOUSE FLY (*Musca domestica*).

a, Mandible of larva *b*; *c*, anterior spiracles of larva; *d*, eggs; *e*, puparium; *f*, spiracular remnants.

ova; each female laying as many as six batches during her life. The ova hatch in from eight to twenty-four hours. The larvæ are dirty-white footless grubs, which cast their skin twice, and then in a week they become full fed and stop feeding. When mature they are about half an inch long. The skin then hardens into a brown puparium case. This stage, still in the dung-heaps, &c., may last three days only, depending on the weather. Larvæ, pupæ, and flies may be found all the year round. The house-fly lives by sucking up its food. They annoy us and our animals to feed off the sweat. Numerous other species of Muscidæ are called house-flies, the technical differences of which we cannot enter into. The house-fly is destroyed wholesale by a fungus, *Empusa musca*, the spores of which germinate in the body, and the mycelia grow out, killing the fly and fixing it, as we so often see, to the window-panes. The importance of the house-fly is because it carries the germs of enteric fever and suchlike.

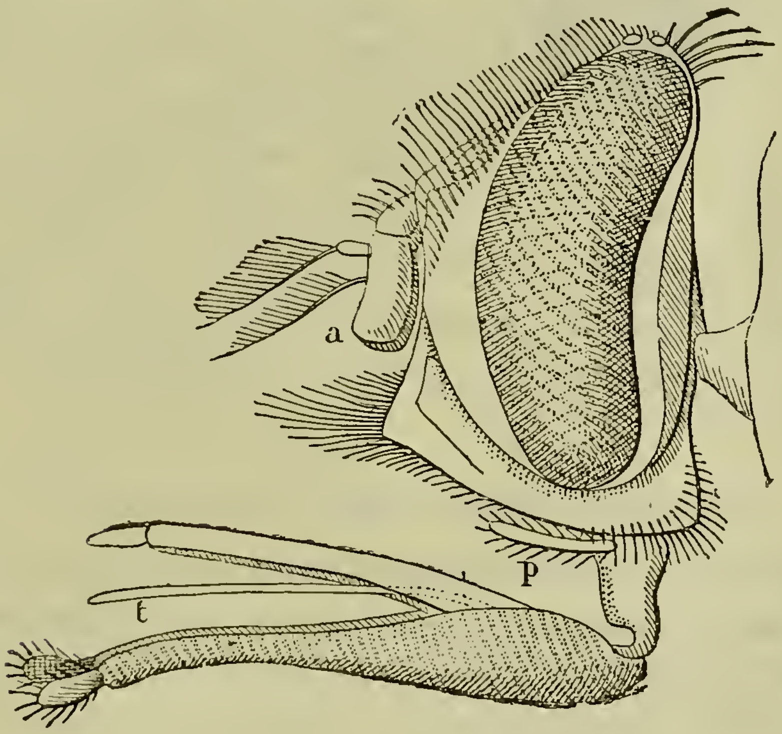

FIG. 145.—HEAD OF *Stomoxys*. (Delafond.)
a, Antennæ; *p*, maxillary palp; *t*, proboscis. (From Par. Dis. Ani., Fleming.)

Another noxious fly sometimes found in houses, stables, cowsheds, and pigstyes is called the Biting Fly (*Stomoxys calcitrans*), which sucks the blood out of animals, and even attacks man: it is one of the true Muscidæ. It is provided with a sharp piercing proboscis (fig. 145) with which it penetrates the skin of its victim.

Ticks, Forest Flies, &c. (Eproboscidea).

The Eproboscidea are the Sheep-ticks, Forest or Horse Flies, and Bird Flies. They are generally called Pupipara, and present many peculiarities, which can only briefly be referred to here. Some resemble spiders in appearance, but the number of their legs soon identifies them. They are all parasitic in habits, living upon warm-blooded animals. Some are quite apterous, as the sheep-tick and bee-louse. They are chiefly remarkable in that the female produces her young singly, not as an ovum but as a nearly mature larva or puparium.

The Sheep-ked (Melophagus ovinus).

Amongst the parasites which are so numerous and destructive to sheep we find one of these Pupipara, the well-known Sheep Spider Fly, "Ked," or Sheep Tick (fig. 146), which, although never producing fatal results, yet causes much annoyance to the ewes, and more still to the lambs. We find this pest living amongst the wool, getting close to the skin when we try to catch it. In shape a sheep-ked is flat, with a squarish head, square thorax, and a flat bag-shaped abdomen. There are no wings or halteres, and the whole insect, especially the abdomen and legs, is very bristly. The colour is brown, greyish-brown on the abdomen. The feet have a pair of strong hooked claws, each with an accessory side claw and a feathered bristle. The sheep-ked lays her puparia amongst the fleece. The true ova hatch in the body of the female and develop there, until the puparium state is assumed, when each puparium is passed out as a bright, shiny, chestnut-brown body, oval in form, with truncate ends. When the female deposits a puparium she fixes it to the wool by a gluey substance, so that it cannot fall off. Taschenberg says each female may produce eight such puparia; the author has found that seldom more than four are so produced. The spider-like fly comes from these shiny, glass-like puparia in from three to four weeks. They get on to the sheep either from one sheep coming in contact with another or from the ground, where they may hatch out from the fallen puparia. They get to the sucking lambs from the ewes, and often annoy them immensely. The winter is passed in the puparium stage.

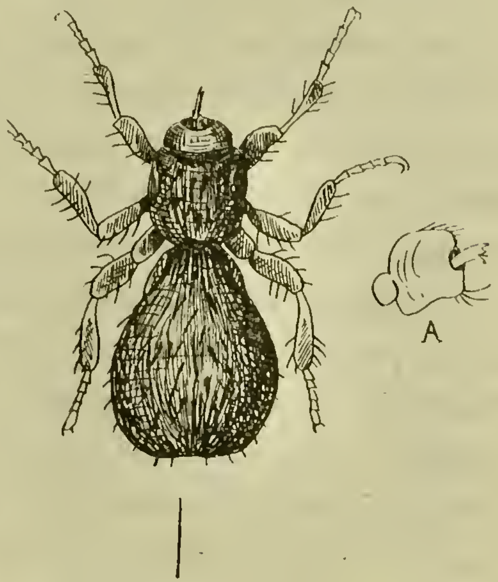

FIG. 146.—SHEEP-TICK (*Melophagus ovinus*).

A, Antenna.

Remedies.—This and all sheep external parasites are readily amenable to treatment. Dipping soon destroys all these parasites, but as a rule two dippings are necessary, the second about a month after the first, so as to kill off those hatched from the puparia.

THE FOREST OR HORSE FLY (HIPPOBOSCA EQUINA).

The Forest Fly is only of local importance, as it is seldom sufficiently abundant to be obnoxious except in the New Forest, where it is a terrible pest to horses and cattle, and in parts of North Wales, especially in the Snowdon area, where I have seen it in great abundance, notably in the Pen-y-Gwryd and near Quellyn Lake. It was well known to many of the local drivers.[1] The fly is the fourth of an inch long and flattish in form, with a hard leathery skin, deep brown in colour with paler mottlings; the head is dull yellowish except on the face, where it has a dark stripe; the thorax has a pale spot on the scutellum, and yellowish-grey markings along the sides and posterior part; the abdomen is bristly, brown above, paler brown to grey below; the two wings are opaque, longer than the abdomen, and have thick brown veins along the costal region; the legs are long and bristly, tawny yellow in colour, and banded with brown. The foot is remarkable, and consists of a pair of large claws, with an appendage on each, outside; there is also a long bristle-like thread coming out beneath the claws, and a curious flap-like process between. These flies use their wings but weakly, only flying on the horse and from part to part of the same animal. They cling to the hairs and run about, pulling the hair, and cause much irritation by so doing as well as by blood-sucking. Like all Pupipara, the Forest Fly deposits round puparia, which are notched at one end. There is but one larva in the female, which lives there until the puparial skin is formed, when the puparium is laid, the larva inside soon turning to a pupa. In four weeks the fly emerges from this case. Animals soon get used to their presence, but a strange horse will become most restive when they settle upon it, especially when (as often happens) the belly is attacked. Little can be done to keep them off, except sponging the horse over with a paraffin sponge.

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[1] Miss Ormerod also records it from Breconshire.

Two other species are sometimes troublesome—namely, the Fowl-fly (*Ornithomyia avicularia*) and the Bee-louse (*Braula cœca*); the former a winged species that attacks birds, the latter a wingless reddish-brown insect parasitic on the hive-bee.

Several others (*H. maculata*, *H. rufipes*, &c.) attack animals in warm climates.

Aphaniptera or Fleas (Pulicidæ).

Several species of fleas are found in Great Britain, all partial parasites, living upon man, animals, and birds. Fleas are apterous Diptera which are perhaps more nearly related to the Fungus Gnats (*Mycetophilidæ*) than to any other Diptera. Pulicidæ have a sucking and piercing mouth by which they draw out the blood of their hosts. The body of the flea is flattened from side to side, and the legs are well developed to enable them to perform their hopping movements. Some have compound eyes (*Trichopsylla gallinæ* and *Pulex irritans*), others have none (*Hystrichopsylla talpæ*, the Mole Flea). The eggs or "nits" are laid in dust and dirt, and the larvæ are pearly-white fourteen-segmented grubs, with a large brown head, and pupate where they live, as small brown chrysalids. Some feed on scurf, hairs, feathers, and other epidermal productions. Many of the species can be easily identified by the number of spines in the curious comb-like structure on the prothorax.

THE HEN-FLEA (TRICHOPSYLLA GALLINÆ).

The Hen-flea is often very troublesome in fowl-roosts. It is a species common to several birds, and is dark-brown in colour. We find them most abundantly in dirty fowl-nests, especially where the houses are damp and badly ventilated and lighted. Hen-fleas live in the nests, where in the corners and crevices the nits are deposited; the larvæ and pupæ are found amongst the straw, feathers, and dung in the nests. The fleas feed off the birds at night, sucking their blood, and produce great irritation. These insects are very injurious to setting hens, and often cause them to neglect their eggs. The small white maggots have a curious little process, the "post-frontelle," on their head, on coming from the egg, by which they force their

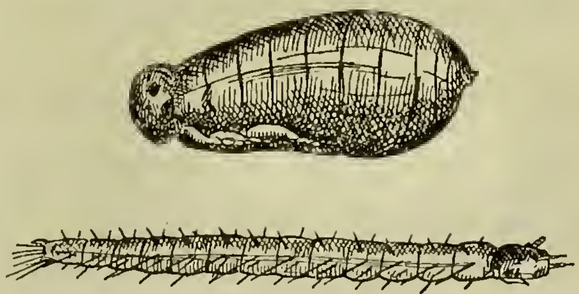

FIG. 147.—LARVA AND PUPA OF HEN-FLEA (*Trichopsylla gallinæ*).

way out of the egg-shell: there are a few scattered hairs over the larva, which lives about three weeks.

Prevention and Remedies.—It is very important to keep fowls' nests clean; then fleas cannot breed there, and can be easily kept down. By using wood-wool instead of straw we shall seldom be bothered by them in our fowl-roosts. Persian insect-powder is a good insecticide to keep them off setting birds, just dusted over the boxes before the eggs are put in and the hens commence to set. In fact, keeping the hen-houses clean will stop this insect from doing any harm.

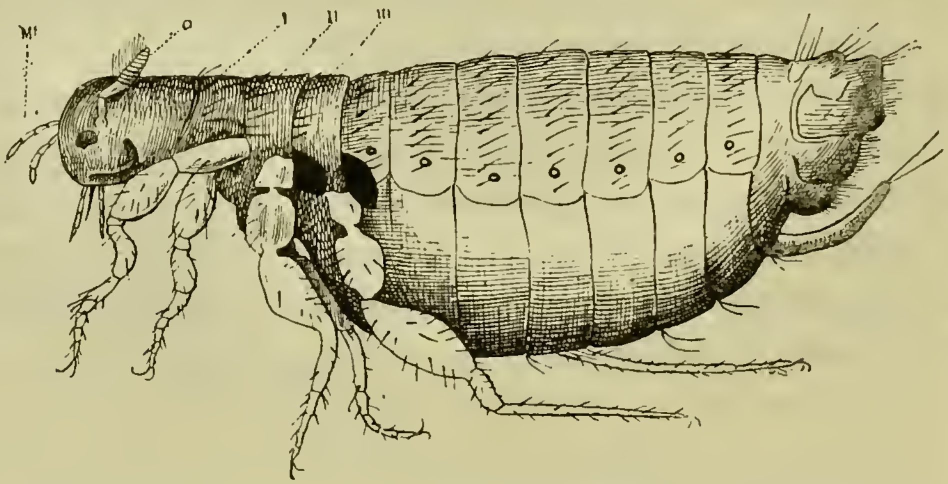

FIG. 148.—THE HEN FLEA (*Trichopsylla gallinæ*) (greatly magnified).

The Dog-flea (*Ctenocephalus canis*), also the Cat-flea (*C. felis*), should be kept off the animals if possible. Carbolic soap baths are perhaps the best remedy. No other species are very noxious in these islands except the Human Flea (*P. irritans*), but one must remember that the Rat Fleas (*Ceratophyllus fasciatus*, *Ctenopsylla musculi*, *Xenopsylla cheopis*, &c.) carry plague.

THYSANOPTERA.

THRIPS, OR BLACK FLY.

The *Thripidæ*, or Black Fly, sometimes called Thunder-fly, form a distinct order of insects, characterised by having four
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thin, narrow, fringed wings and an imperfect suctorial mouth. The metamorphosis is slight. Several of them are injurious to crops and fruit, and are equally obnoxious in greenhouses. Thripidæ are minute dark insects in their adult state, and feed by suction, although the mandibles are represented by a pair of needle-like processes. One species, *Thrips cerealium* (fig. 149, 1 and 2), is often harmful to corn. The larva and pupa are similar in shape to the adult, but are smaller and differ in colour: the larva is deep yellow, with two dusky spots on the thorax; the pupa is pale yellow, with white legs, antennæ, and wing-cases. The eyes and ocelli are reddish. The adult is deep black and winged in the female, apterous in the male. The legs are paler, and the two-jointed tarsi terminate in a little gland, hence they are sometimes called "Bladder-feet." The Corn Thrips is about $\frac{3}{4}$ of a line long. This pest feeds off the haulm, between the sheathing leaves, and off the developing grain, and is especially noticeable in the furrow of the wheat seed. They cause the grain to shrivel up, and often produce a white sickly appearance, similar to a disease caused by them in grass in Canada. Another species, *T. ochraceus*, is frequently most harmful to melons, cucumbers, tomatoes, &c., under glass.

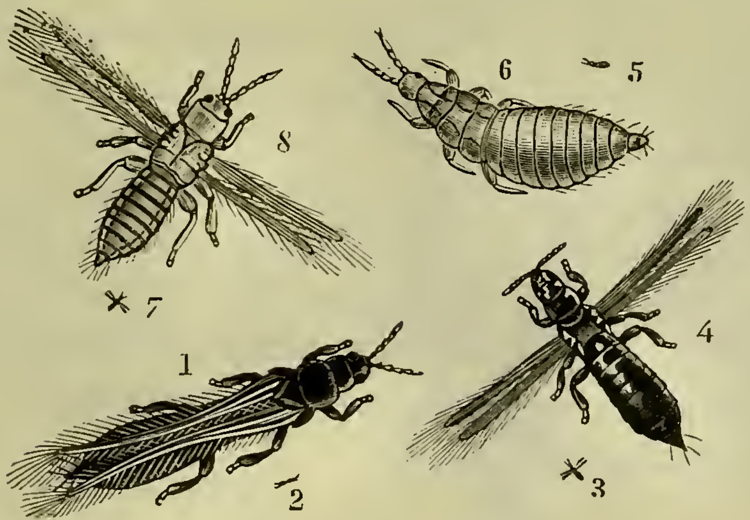

FIG. 149.—THRIPS.

1, Female *Thrips cerealium* with wings closed; 4, with wings expanded; 2, 3, 5, 7, nat. size; 6, larva of *T. minutissima*; 8, *T. minutissima*. (Curtis.)

The potato is attacked by *T. minutissima* (fig. 149, 6 and 8), but it seldom does much harm: the yellow larva has black eyes in this species, the pupæ are also of the same colour; the adult is pale-brown, with almost white wings, and is only ⅓ of a line in length. The Thrips hibernate at the roots of grass and amongst rubbish, and come forth in spring, when they commence to lay their eggs. Numbers of generations are produced in the year. The eggs are very small white bodies, cylindrical, and rounded at one end, and usually laid in slits cut in the plant tissue. Several species of Thrips damage plums, apples, and pears; the chief is *Euthrips pyri*.

Prevention and Remedies.—After an attack of Corn Thrips the stubble should be burnt, and the grass at the headlands and hedgerows cleared and burnt in the late autumn. In greenhouses frequent syringing with clean water will keep this pest in hand, but tobacco and soap wash is the best remedy. In bad attacks greenhouse plants are best dipped in a mixture of the latter. Fumigation with tobacco is another excellent remedy in glass-houses. In fruit plantations it can be controlled by spraying with the same wash.

HEMIPTERA.

Bugs, Plant-lice, Scale Insects, Etc.

The Hemiptera are the Bugs, Plant-lice, Scale Insects, Cicadas, and Lice (*Pediculi*), &c. The characteristics of the Hemiptera are chiefly found in the mouth and the wings. The mouth parts of all the Hemiptera are adapted for piercing and sucking. The mouth is formed of a jointed rostrum made up of an elongated labium, which forms a jointed sheath for the lancet-shaped mandibles and maxillæ. It is by means of this piercing suctorial mouth that the Bugs and Plant-lice puncture the rind of plants and then proceed to suck out the sap, often leaving behind a distinct scar where the proboscis has entered (fig. 150, *a*). The majority live on vegetable juices, but some suck the blood of both vertebrate and invertebrate animals and man, and even carry disease. Four wings are present as a rule; but these may be reduced to two, as in the male Scale insects, or none, as in some bugs, plant-lice, and female Scale insects. There are two distinct types of wing—one in which the basal half of the fore-wing is leathery, the other half transparent, known as a *hemielytron;* in the second it is all clear and membranous. The former type is found in the section of Hemiptera called *Heteroptera* (fig. 159), the latter in the *Homoptera* (fig. 151). At one time these two sections were considered two distinct orders of insects. They are now united together under the order Hemiptera.

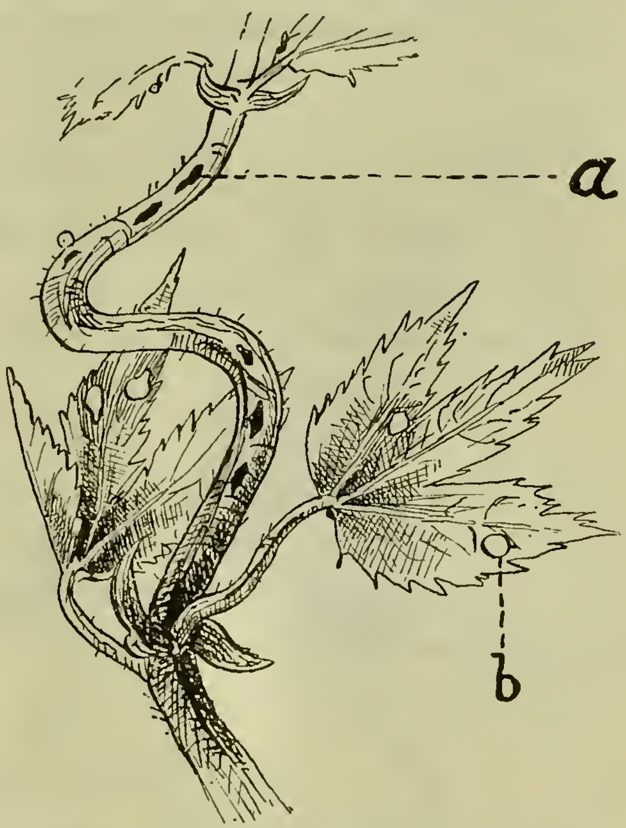

Fig. 150.—Hop damaged by Hemiptera-Heteroptera.

(*a*) By *Calocoris fulvomaculatus;* (*b*) by *Anthocoris nemorum;* showing scars (*a*), and holes (*b*).

The Hemiptera undergo an incomplete metamorphosis, there being little difference between the larva, pupa, and imago in many genera. The pupæ are always active except in the Scale insects and Snow-flies. The larva, which also resembles to a certain extent the adult, moults its skin several times, and then, if it is destined to become a winged form, it develops rudiments of wings as small bud-like lateral outgrowths on each side of the thorax, the pupal stage, which after a time casts its skin and becomes the adult (*vide* fig. 159). The ova of the Hemiptera are often beautifully sculptured bodies.

Many of this order are extremely injurious, such as the Aphides or Plant-lice, many of the "Bugs" (*Heteroptera*) and Scale insects (*Coccidæ*), Snow-flies (*Aleyrodidæ*) and Leaf-hoppers (*Typhlocybidæ*). Many of the *Capsidæ* (Land Bugs) also attack fruit. There are generally considered to be three groups of Hemiptera, as follows:—

1. *Homoptera* (fig. 151), wings always clear and membranous when present, and the rostrum attached to frontal region of head = *Aphididæ*, *Coccidæ*, *Psyllidæ*, &c.
2. *Heteroptera* (fig. 159), wings half leathery at the base, membranous at the tips, and the rostrum springs from beneath the head = the Bugs (*Reduviidæ*, *Lygæidæ*, *Capsidæ*, *Cimicidæ*, &c.)
3. *Anoplura*, which are all devoid of wings and parasitic = *Pediculidæ* or Lice.

The **Homoptera** contain the most injurious species of this order. They are exemplified by the Plant-lice (*Aphididæ*), the Scale insects (*Coccidæ*), the Snow-flies (*Aleyrodidæ*), and the Suckers (*Psyllidæ*.)

PLANT-LICE (APHIDIDÆ).

Plant-lice are amongst the worst enemies the farmer, fruit-grower, and gardener have to contend with. They live entirely upon the sap of plants, which they draw from the leaves, blossom, stem, and roots. The structure of an Aphis is simple. The body is usually plump, and has usually two tubes called "honey-tubes" or "cornicles" on the back towards the tail. Out of these is passed a gummy liquid, the "honey dew," which falls upon the leaves of the infested plants and blocks up their stomata. Aphides have a mealy or waxy substance on the skin which repels water. Winged and wingless females occur, the males being also often winged. Parthenogenetic reproduction takes place; both oviparous and viviparous females occur. The wingless forms are generally asexual, and so are the summer winged females. Winged males and oviparous females also occur. Ova are usually laid only in the autumn by the oviparous female after fertilisation by the male. The tarsi are of two segments, and the wings contain very few veins, by which the Dolphins, as they are called in Kent, are partly classified. The reproductive powers of these insects are enormous as well as peculiar. The wingless female, starting in the spring, produces with great rapidity living young without the agency of a male; these asexually produced young or lice soon grow sufficiently to start reproducing again, and so on for eight or nine generations. As a rule, a plant becomes smothered by these wingless forms; and in the summer some send out little bud-like growths from the thorax, rudimentary wings, a pupal stage, and from these active pupæ come forth winged females, which fly off to other plants. These winged females are also viviparous, and produce again asexually living

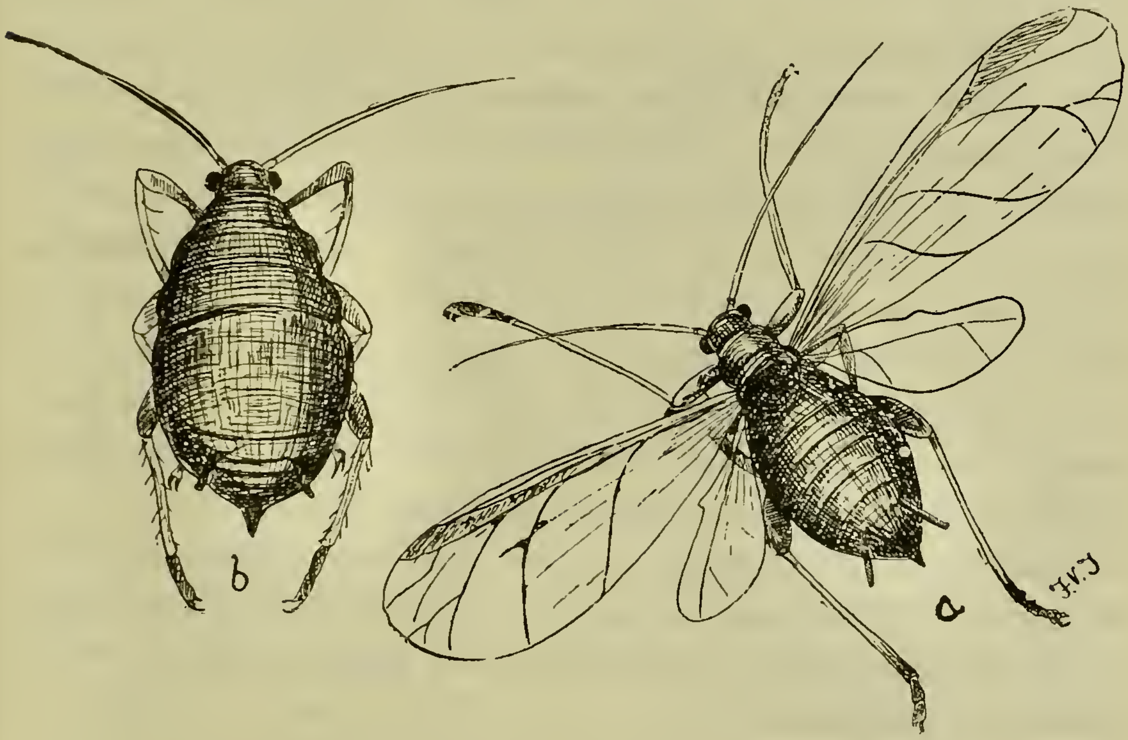

Fig. 151.—Cherry Aphis (*Myzus cerasi*).
a, Winged ♀; *b*, apterous ♀.

young, and so on until the autumn, when a third kind of female appears, the oviparous female, and also a male. After the male has fertilised the female aphis, she deposits a few eggs upon the plants, which remain over the winter. These eggs mostly hatch out in the spring. But some Dolphins also hibernate as queen or mother females, and commence to reproduce at once on the return of warm weather. There is often not much difference between the young (larvæ), or lice, as they are called, and the viviparous female; but larva, pupa, and adult may generally be distinguished by variations in structure and colour. Some Aphides produce galls (*Schizoneura ulmi*, *Pemphigus spirothecæ*, *Chermes abietis*, &c.); others live underground (*S. lanigera* and *Phylloxera devastatrix*); others live in ants' nests. The life-cycle of Aphides is often very complex. Most have two or more host plants between which they migrate. The Hop Aphis, for instance, winters in the damson and flies to the hop for the summer; the Elm Leaf Aphis (*Schizoneura ulmi*) flies to the roots of Ribes; the Mealy Plum Aphis (*Hyalopterus pruni*) to rushes and water grasses.

The three chief groups are the *Aphidinæ*, which have the third vein of the front wings twice forked; the *Schizoneurinæ*, which have this vein once forked; and the *Chermisinæ*, which have this vein absent.

The Bean and Poppy Aphis, Black Fly, or Collier (*Aphis rumicis*).

A common bean infestation is that caused by one of the plant-lice, known as the "Collier." This aphis appears first when the beans come into blossom, and especially blights broad-beans. These Colliers collect on the heads, where they breed rapidly, cover the plants with a black sticky mass, and, if they spread down low, quite spoil the crop. These plant-lice are black in the wingless female state. The winged females are sometimes rusty-brown, with green honey-tubes, but more usually they are quite black; the male is black and winged; the young dark-grey to black; and the pupæ slaty-grey, with black wing-cases and white spots and patches on the black abdomen. They are also found on mangolds, poppies, hops, chamomile, euonymus, docks, &c., from which they have taken various specific names, having been supposed to be distinct species. This aphis winters on docks and euonymus, then flies to the beans and poppies, and later to mangolds and other plants.

The attack of this "louse" can easily be checked, if taken in time, by picking off the infested tops of beans and putting them carefully into a pail of lime, so as to kill them before they spread low down. Many plant-lice, like the above, have several food-plants.

The Hop Louse (*Phorodon humuli*).

The Hop Aphis (*Phorodon humuli*) first makes its appearance on the hops as a winged viviparous female, the so-called "fly." This takes place from the middle of May on into June. The "fly" settle on the top growths, and at once commence to produce living young, small pallid larvæ, spoken of as "lice" or "nits." These grow into the wingless viviparous females, which continue to produce living young for several generations. Now and again a winged brood has been known to appear in summer on the hops, and these fly to other hops and produce similar lice, but this is rare. In September the Hop Aphis all become winged, and these fly to the damsons, sloes, and some plums, where a sexual generation of males and females is produced, the ovigerous females laying eggs in the axils of the buds. These hatch out in spring and feed on the foliage of the prunes, and late in May produce a winged viviparous brood, which fly off to the hops. Green apterous viviparous lice have been found on hops (Ormerod) previous to the advent of "fly," but the part they play has not been found out. They have little or nothing to do with the usual aphis blight. The Hop Aphis is easily controlled by spraying or washing with soft-soap and quassia or, better still, tobacco wash.

Woolly Aphis (*Schizoneura lanigera*).

The Woolly Aphis is a widespread species affecting fruit-trees. Its presence can easily be detected by the quantity of white cottony wool produced by the larvæ and apterous females. We often, especially in west-country orchards, see this white excretion hanging from the trees in great festoons. The trees suffer severely. Apple-trees are those that suffer most, but pear-trees and hawthorn

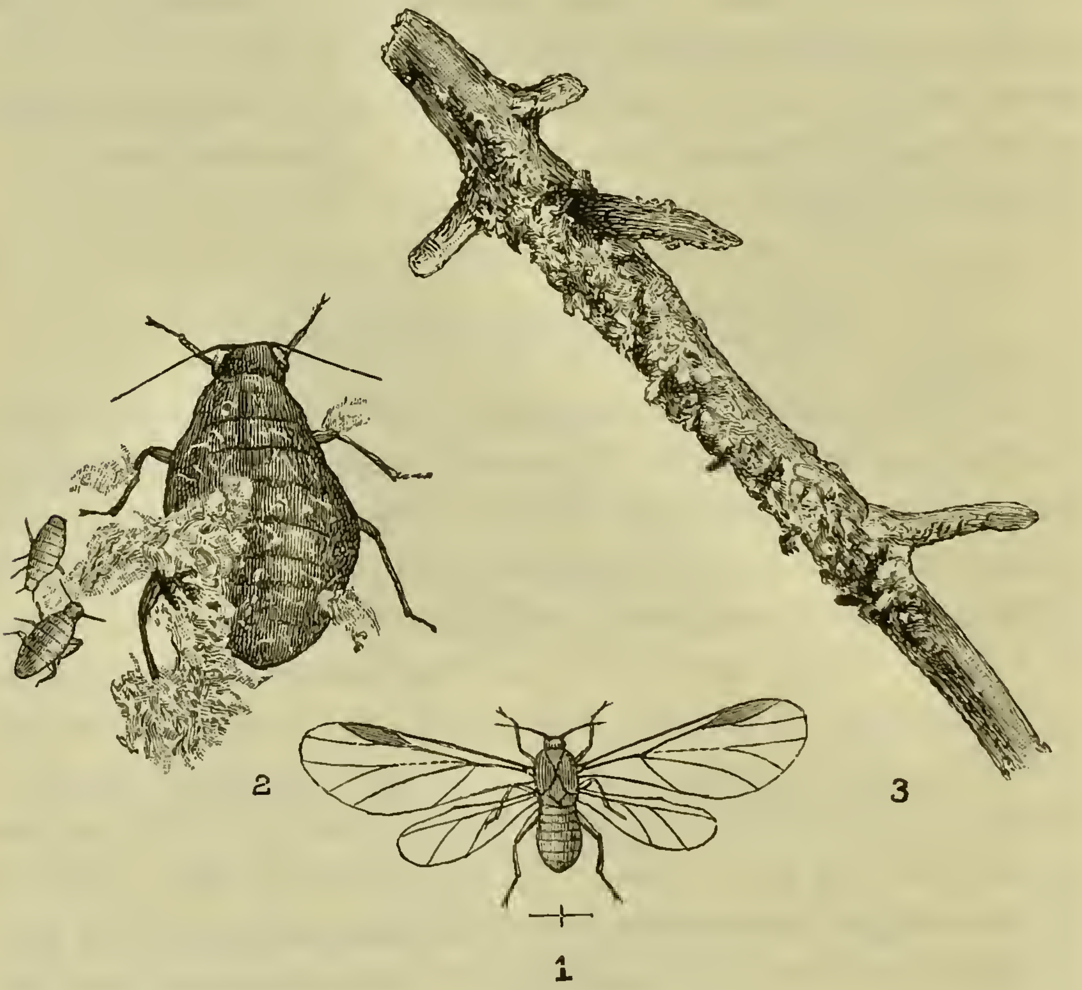

Fig. 152.

1, Winged female, Woolly Aphis, magnified ; and line showing natural size. 2, Wingless viviparous female, magnified. 3, Apple twig, covered by woolly aphides.

may also be attacked. These plant-lice cause cankered growths to appear on the boughs; the new wood is their favourite seat of war, where they can easily plunge their beaks into the soft rind. This wound, at first boil-like, usually ends by splitting; deep cracks and crevices are formed, in which the insects seek shelter. Growth is checked; the crop does not mature, and often the trees fail under the attack. If we examine this white wool, we shall see that it proceeds from the backs of the lice and females, as fine threads of wax. Amongst this excretion we observe the orange-coloured lice, which get blown from tree to tree with the wool by the wind, and even from orchard to orchard. The adult females are slaty-grey to plum colour, and have no cornicles; these adults secrete a little wool, but are also well protected by mealy powder and little globules of an oily nature. In July and August there may appear winged females, and in autumn an oviparous female and male sometimes occur. Very few eggs are laid, however; each oviparous female only laying a single black ovum on the apple-tree, so as to secure the continuity of the species. The majority pass the winter as mother-females in crevices in the bark and at the bottom of the cracks they have produced, more or less protected by their wool from the cold. This species also attacks the roots of the apple-tree. There is a ground form of *S. lanigera*, like the ground form of the vine phylloxera. The aerial form passes down to the roots in late autumn, and the subterranean form crawls up again in spring. Thus as long as we have the root form present we shall never eradicate this pest on our apple-trees.

Prevention and Remedies.—We notice this disease chiefly rampant in neglected orchards, where the trees are cramped together, and the trunks and boughs covered with moss and lichens. Keeping the trees properly thinned, with plenty of room for air, and clean, will prevent much damage from this pest. All rough bark should be cleared off, mosses and lichen destroyed by the caustic washes mentioned in the Appendix.

The aphis on the trees may be killed by spraying *with force* with paraffin emulsion, or better still, tobacco wash. The ground form may be kept from ascending by banding with Tanglefoot. In Australia and South Africa apples are only grafted on Northern Spy or Majetin stock; the roots of these are immune.

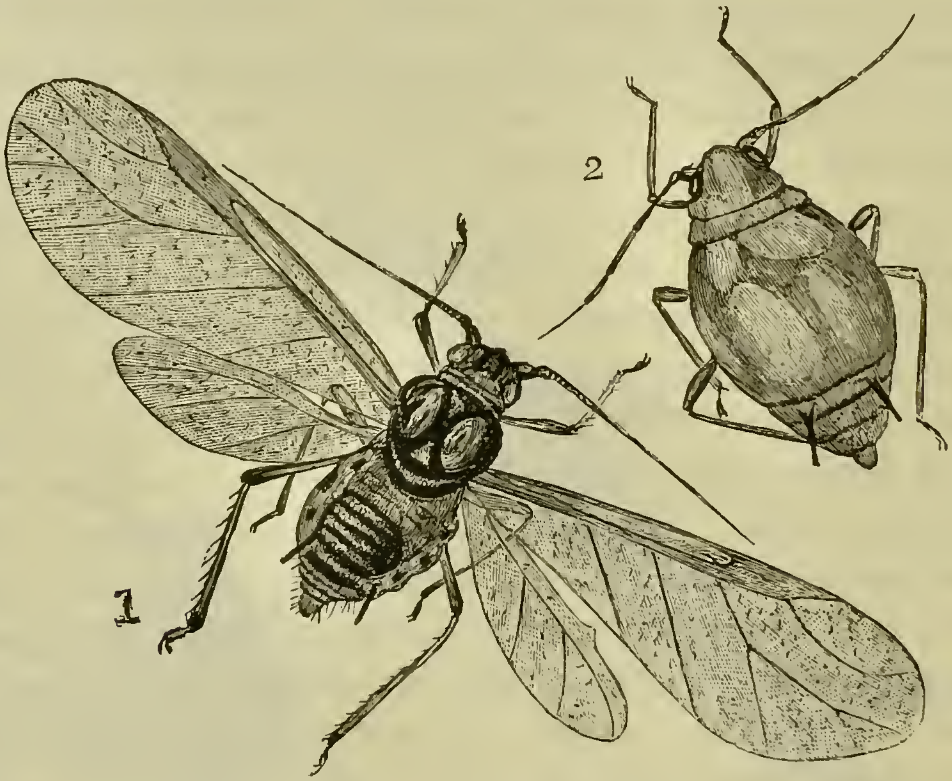

Fig. 153.—Plum Aphis (*Aphis pruni*).
1, Viviparous female; 2, ovigerous female. (Whitehead.)

Numerous other plant-lice attack crops and fruit, among which we may mention the Corn Aphis (*Macrosiphum granaria*); the Cabbage Louse (*Aphis brassicæ*), which crinkles up the cabbage leaves, forming a mealy mass of lice; the Plum Louse (*A. pruni*) (fig. 153), curling up the leaves of the plum; the Cherry Louse (*Myzus cerasi*) (fig. 151), which collect on the shoots of cherries, forming black groups and discolouring the fruit with their excrement; the Currant Aphides (*Rhopalosiphum lactucæ*), &c. All can be destroyed by the same washes, and need no further comment here. (*Vide* Appendix II.)

Scale Insects (Coccidæ).

These Hemiptera are peculiar in many respects. The females are mostly apterous apodal degenerate creatures, devoid of antennæ, and often lie hidden under a scale-like mass, formed by the excretions of the insect and the cast skins of the larva (exuviæ). They have a very long thread-like beak, which is thrust into the bark, leaf, or fruit of the plant, most females being fixed during the whole of their life, after the larval stage is passed. The males (fig. 155, i) are winged, having one pair only, the second pair being hook-like processes. The male scale (vi) is quite different from the female scale (v) in form. Some Coccids, such as the Mealy Bugs and Soft Scales, form no scale, and are active in the former, but become sedentary in the latter, but are then covered with a quantity of mealy powder and wool or a hardened skin. During winter some of our outdoor scales are in the egg state (Mussel Scale); the ova are minute dust-like bodies found under the scale; others pass the winter as immature forms (*Lecanium*, &c.) In warmer and tropical climates scales breed all the year round, and so they do in hothouses in this country. The young scale-insects are active six-legged larvæ (iv), which wander about for a time and then settle down and may form a small scale, gradually increasing in size. If this larva is going to become a female, as it moults it loses its legs, antennæ, &c., and usually degenerates into a sedentary apodal creature. But if the larva is going to become a male, it enters a propupal stage, a new set of legs, &c., being formed, and wings appear as bud-like outgrowths. They are very numerous and destructive in warm climates, where fruit-trees are encrusted with them. Perhaps the most destructive is the San José scale (*Aspidiotus per-*

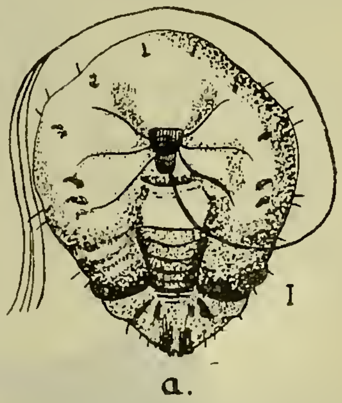

Fig. 154.—Female San José Scale. (After Howard.)

niciosus) (fig. 155, i, ii, iii), which attacks all fruit-trees and numbers of other deciduate trees and various plants. One female has been shown to account for 3,216,080,400 young in the year under favourable conditions (Lintner). Numbers of species are injurious in our hothouses, such as the Greedy-scale (*A. camelliæ*) and the Oleander-scale (*A. nerii*), and the two Mealy Bugs (*Dactylopius citri* and *D. longispinus*), but out of doors only two or three ever do much harm. The most prevalent is the Mussel-scale (*Mytilaspis pomorum*) on apple and pear, the Brown-scale (*Lecanium persicæ*), the Oyster Shell Back Louse (*Aspidiotus ostreæformis*), and the Woolly Currant-scale (*Pulvinia vitis*), the second on gooseberry and currants, the third on plums, the last on currants, vines, Pyracanthus, &c.

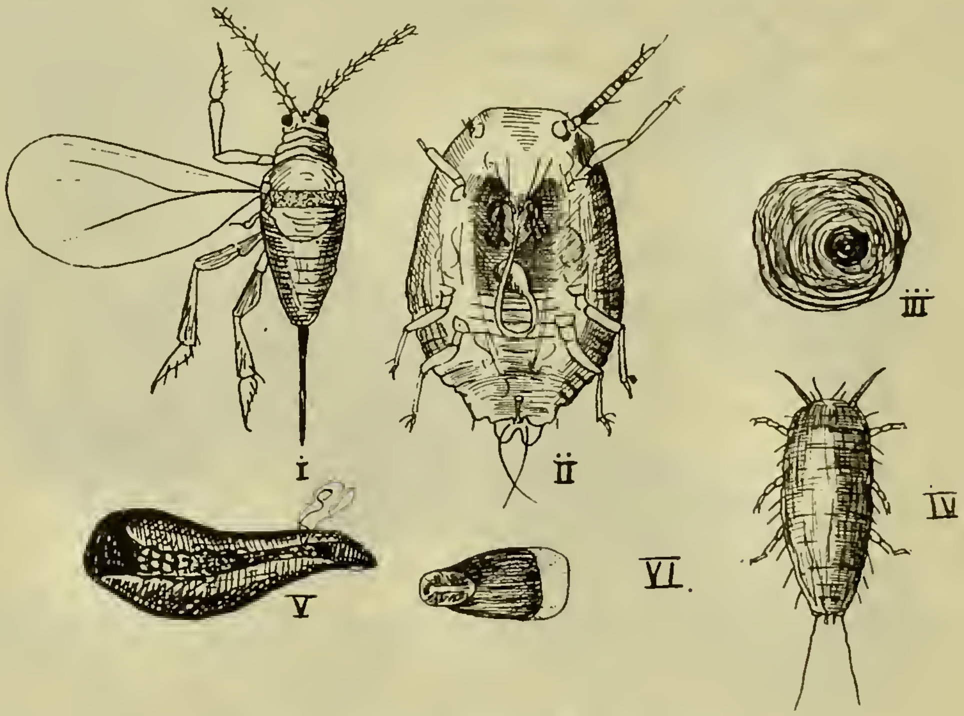

FIG. 155.—SAN JOSÉ AND MUSSEL SCALE.

i, Male San José scale ; ii, larva of same ; iii, female scale ; iv, larva of mussel scale ; v, female mussel scale ; vi, male mussel scale. (i, ii, iii after Marlatt and Howard.)

The Mussel-scale (*Mytilaspis pomorum*).

This scale insect was at one time placed in the genus *Mytilaspis*, all of which are elongated scales, more or less mussel-like in form. It is now, however, placed in the genus *Lepidosaphœs*, and under the specific name *ulmi*. The mussel-scale is brown, from $\frac{1}{12}$ to $\frac{1}{8}$ of an inch long, and of nearly uniform width, except in the front, where it tapers to a point. Sometimes the scales are straight, at others curved. The eggs are creamy-white, and may number between eighty and ninety, being scattered about under the scale: we find them in the winter. There is only one brood: the young six-legged larvæ (fig. 155, iv) appear in June, and soon settle down to form fresh scales. The male scales (vi) are much smaller than the female (v). It is a widespread insect, occurring in America, in Australia, and in S. Africa.

This, like all scale insects, is spread from tree to tree and orchard to orchard by the wind, and on the feet of birds and the back of insects. It has been noticed that some scale-larvæ prefer the back of dark-coloured beetles. Young apple-trees suffer severely from this pest in Britain, and should be thoroughly cleaned before being planted.

Prevention and Remedies.—Scale insects are often difficult to destroy. Fumigation of young stock with hydrocyanic acid gas and the application of caustic washes in winter are most successful remedies. Paraffin emulsion spraying is beneficial for some of the soft scales and when the hard scales are young in summer.

The Brown Currant and Gooseberry Scale (*Lecanium persicæ*, v. *ribis*, Fitch).

This is one of the soft scales, the female's dried body remaining over the egg mass and forming a false scale. It occurs on the twigs of many other trees and bushes besides currants and gooseberries. The dead skin or adult skin with the ova beneath is an oval brown body, convex and notched behind, about $\frac{1}{4}$ inch long. The eggs occur under this brown covering as a yellowish dust with wool, and hatch in autumn into small oval, flattish, pale or red-brown larvæ, which wander about and attach themselves to the bark during the winter and remain dormant; some grow before to some extent. In spring they move to the young wood and leaves and gradually grow into the mature brown females. The male has not been found in Britain.

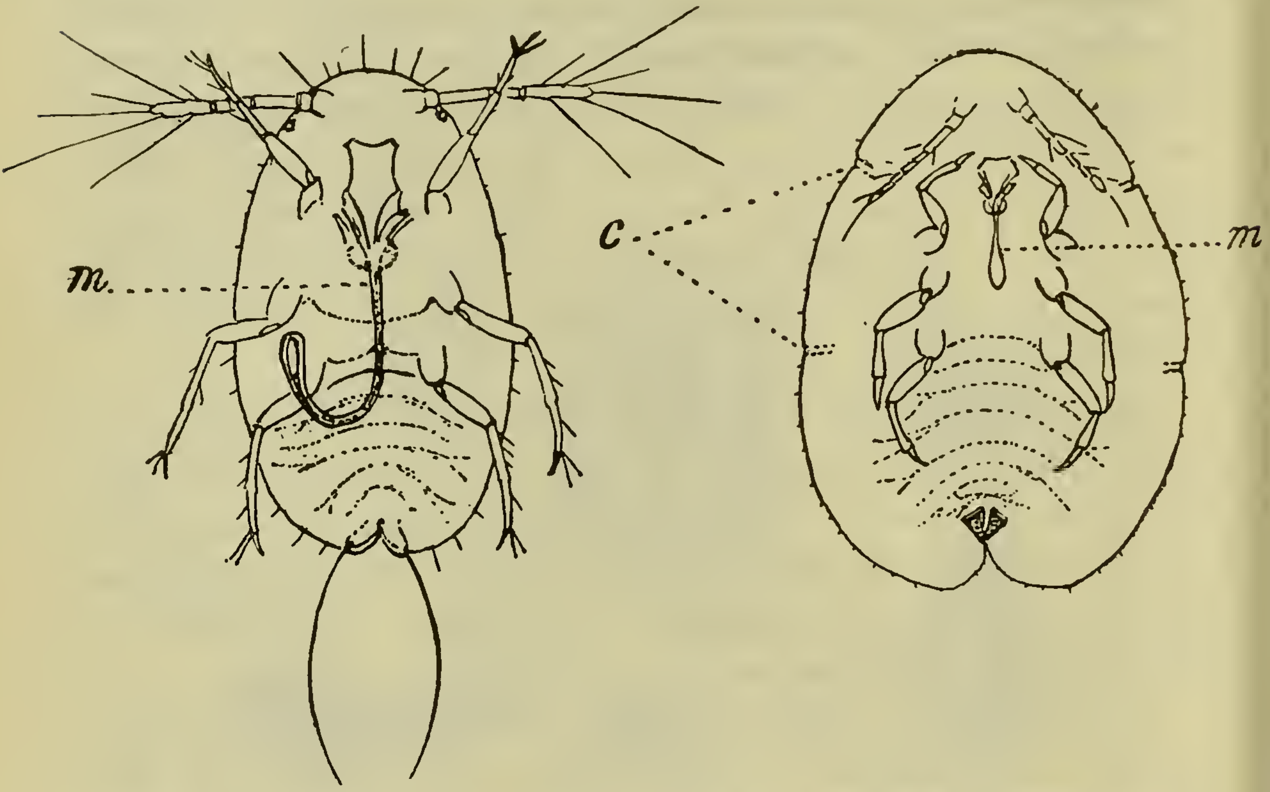

FIG. 156.—THE BROWN CURRANT SCALE (*Lecanium persicæ*, v. *ribis*).

Larva magnified about 50 diameters. *m*, Mouth-parts.

Under-side of young female magnified about 15 diameters. *c*, Channels leading to respiratory tubes (stigmata); *m*, mouth-parts.

Treatment consists of winter spraying with caustic alkali wash, and spring spraying with paraffin jelly.

FAMILY PSYLLIDÆ.

APPLE-SUCKER (PSYLLA MALI).

A great deal of damage is done to the buds and blossom of apples by a small yellowish-green fly called the apple-sucker. The *Psyllidæ* are Hemiptera related to the Aphides, with 8- to

10-jointed antennæ, which end in two short slender bristles. Unlike plant-lice, they have three ocelli, and their legs are formed for leaping in the adults. They live upon the sap, and discharge a fluid in the form of small globules, which are attached by a thread to the tail end of the Psylla. The larvæ are often protected by a cottony secretion as well.

The species infesting the apple is found early in the year in the folds of the buds, and there in their immature form they suck the sap and prevent the leaves and blossom from developing. The larvæ are flattish creatures which we find in the buds, having crawled thither after their exit from the egg. They also block up the buds with their honey dew. They are dark brown and greenish in colour, with red eyes. A true pupal stage is assumed, bud-like wings appearing, until by the

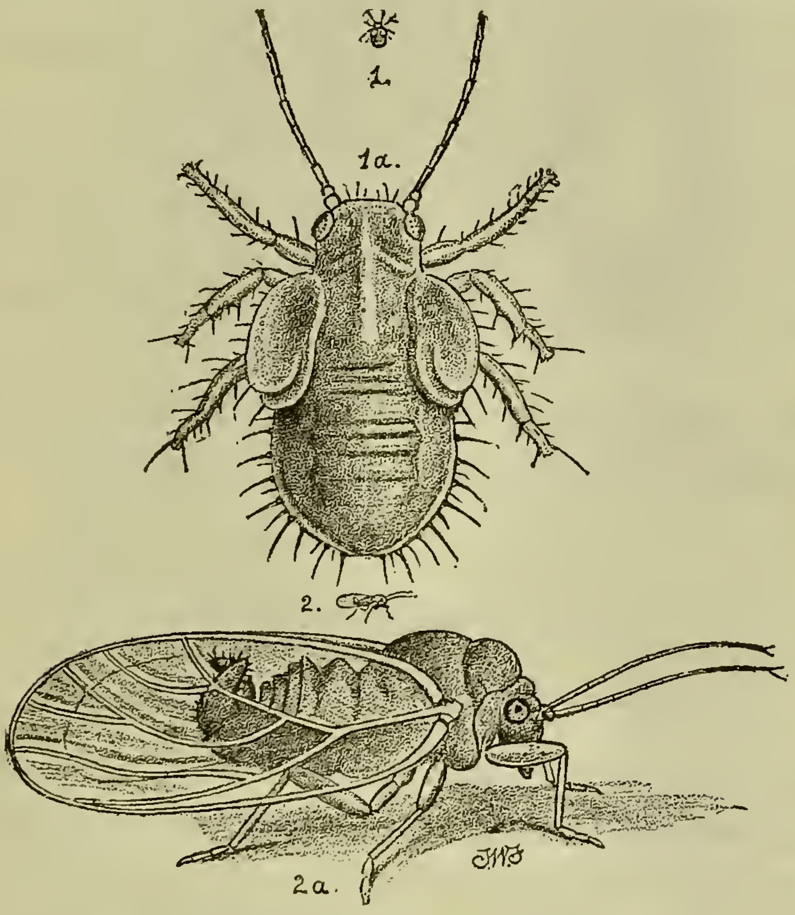

Fig. 157.—Apple-sucker (*Psylla mali*).

1 and 1*a*, Pupa, nat. size, and mag.; 2 and 2*a*, imago, nat. size, and mag. (Whitehead.)

end of a month after their escape from the egg, wings are fully formed. The pupæ are green. The winged Psylla has four transparent wings, and is usually seen about the second week in June, the female being brighter than the male. In size they vary from $\frac{1}{8}$ to $\frac{1}{12}$ of an inch. We may find adults as late as October, but the majority are mature by September, when they pair and deposit their eggs separately upon the bases of the buds and on the youngest apple-shoots amongst the soft hairs. These eggs can easily be seen in the winter, as they are pale in colour. They go on laying until November.

Prevention and Remedies.—This very injurious apple enemy may easily be controlled. If a plantation is very badly infested it should be sprayed in late February with lime and salt wash, and again as soon as the trusses are well open with tobacco wash.

Another species, *Psylla pyrivora*, is now and then found on pears in Britain, and is often destructive in America.

FAMILY **ALEYRODIDÆ.**

THE SNOW-FLY (ALEYRODES BRASSICÆ).

These are also Hemiptera. They are small, moth-like, snowy white, four-winged insects, with a single vein only on the front wings, and their body covered with a fine white mealy powder. The pupa, unlike other Hemiptera, is inactive. The commonest species is the Cabbage Snow-fly (*A. brassicæ*), found at all times of the year on cabbages, beneath the leaves, where they suck out the sap with their beaks, forming brown and yellow patches on them. The eggs are laid singly or in a patch on the under side of a leaf and hatch out in a few days. The young are covered with a transparent glassy white scale which becomes opaque white with two yellow spots. Beneath this scale they turn to a brown pupa in from eight to twenty days, and from four to ten days after the perfect insect appears. The pupal stage is pale yellowish with *red* eyes. The body of the adult is really red and the thorax yellow, but they are covered with a white mealy powder all over. They may breed all the year. Soft-soap washes are the best to kill them. Nicotine has no effect on the young. All outside leaves and stalks of cabbage should be destroyed.

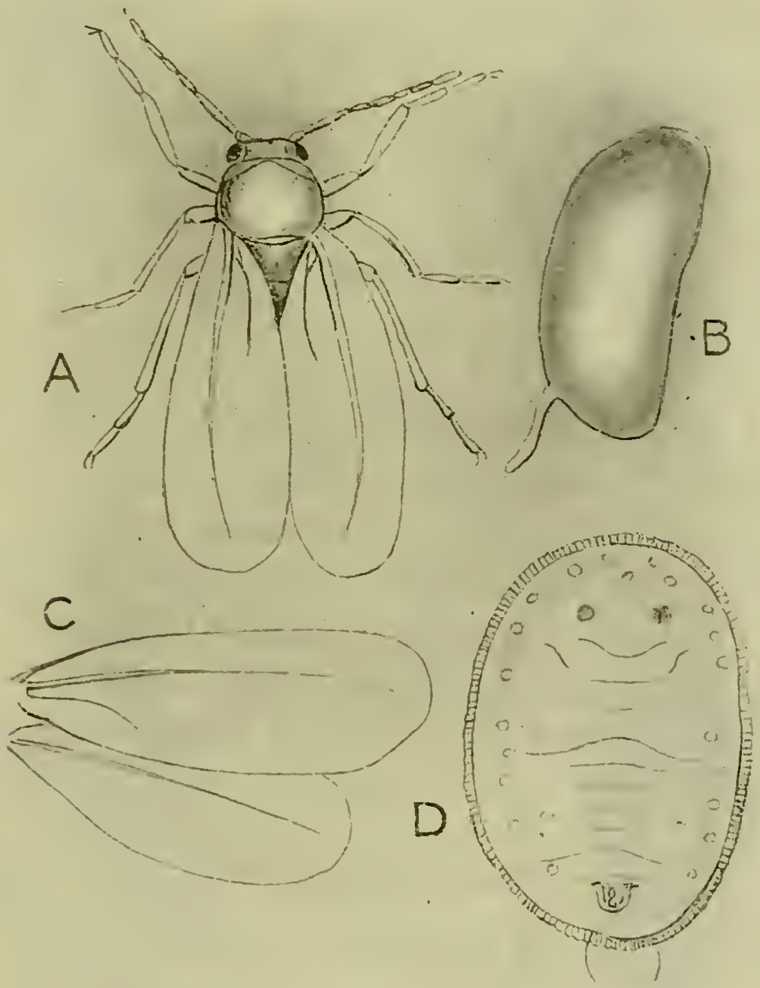

FIG. 158.—A SNOW-FLY (*Alcyrodes*).

A, Adult Snow-fly; B, egg; C, wings of adult; D, immature Snow-fly under scale.

Tomatoes and plants under glass are often attacked by another species (*A. vaporiorum*), and may be checked by fumigation.

FAMILY **TETTIGONIDÆ.**

THE HOP FROG-FLY (EUACANTHUS INTERRUPTUS).

"Jumpers," as these insects are called in the hop-gardens, sometimes do much harm to the hops. When badly attacked the leaves turn yellow and die off. These jumping bugs are provided with four ample wings when adult, and are gaily coloured with brown, yellow, and sometimes red. The larva and pupa are green and yellow. In all stages this insect is very variable in colour. Their exuviæ are often found sticking on to the hop-leaves. Just as in Calocoris (p. 278), they suck out the sap of the leaf and bine, especially in hot dry weather. It is especially upon badly tilled land and stony and light soils that "Jumpers" are troublesome. The damage manifests itself in June by the yellowness of the leaves, their curled appearance, and the stopping of the leading shoots revolving. The abolition of poles has materially checked this pest. Jarring is one remedy we can employ when adults are present, but tobacco wash can safely be used on hops, and this kills the larvæ and nymphæ.

Bugs (Heteroptera).

The second sub-order of Hemiptera are the Bugs. They are united together by the fact that the first pair of wings have their bases leathery, the outer portion being membranous (hemi-elytra). Many of these insects are injurious to plants, and some to man, but some are carnivorous (Nemocoris), and are thus beneficial. The Heteroptera have an incomplete metamorphosis like the Homoptera, the larvæ being apterous, the pupæ having little bud-like wings. They have a long, sharp, jointed rostrum by which they puncture plant-tissues and draw out the sap. Often a distinct scar is left behind where their beak has been inserted, or the tissue may split. The Common Bed-bug (*Cimex lectularius*) belongs to this group, introduced originally into England in 1503, but not until after the fire

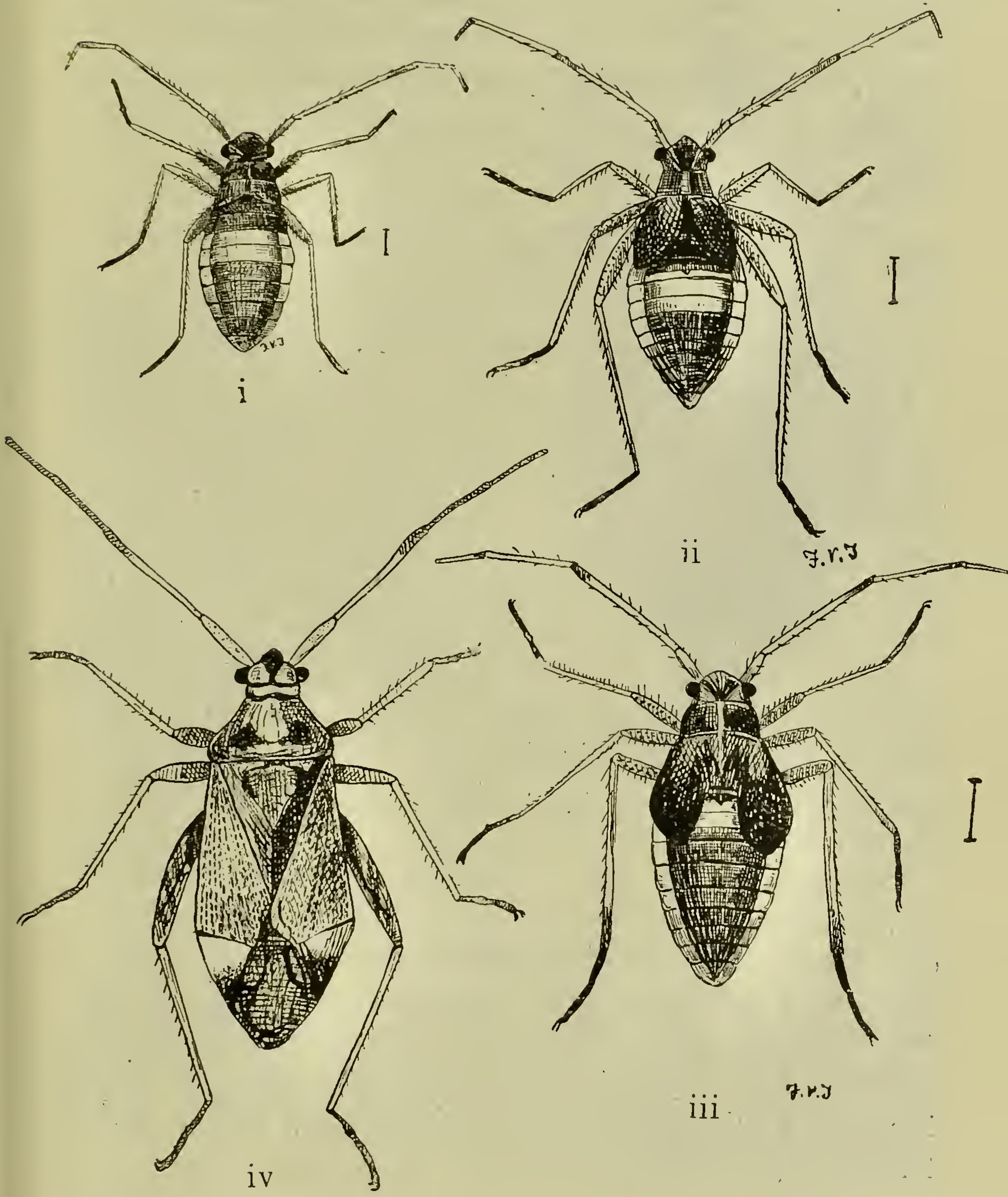

FIG. 159.—NEEDLE-NOSED HOP-BUG (*Calocoris fulvomaculatus*).
i, Larva, early stage; ii, larva, late stage; iii, pupal stage; iv, adult.

of London in 1666 did it become troublesome. It was brought over in foreign timber on the rebuilding of the city. This bug infests animals, it is said, as well as man, and breeds in dust and dirt. Although a number of species of Heteroptera are more or less harmful, only two need be mentioned here—namely, the Needle-nosed Hop-bug (*Calocoris fulvomaculatus*) and the Capsid Bugs attacking fruit (*Orthotylus marginalis*, &c.).

THE NEEDLE-NOSED HOP-BUG (CALOCORIS FULVOMACULATUS).

This bug attacks the hop in all three of its stages, but especially in the larval and adult phase of life. *C. fulvomaculatus* is a bug about one-third of an inch in length and tawny-grey in colour; the young are reddish-brown to chocolate and yellow and green (fig. 159). They lay their eggs in the hop-bine, and hatch out about May. Currants are also attacked by them. They are extremely active, dodging round the poles and bine with great dexterity, and fall readily to the ground when the bine is shaken. They suck the sap from the bine generally at the top, and cause such loss of sap that the upward growth ceases, and numerous low laterals are sent out. When they become winged about July they seem to leave the hops, but many deposit their ova upon wild hops. They hibernate in the larval stage.

Prevention and Remedies.—Early washing when the bugs are in the wingless state and jarring over tarred boards held on each side beneath the bine, together with the destruction of bine after a bad attack, will considerably check their increase. We never see this or Frog-fly attack in gardens where string and wires have superseded poles. The more soap and tobacco in washes for these hardy bugs the better; any wash is useless for the winged adults.

Lice (Anoplura).

The Lice are generally called *Pediculidæ*. These noxious creatures are now considered degenerate Hemiptera. They all possess suctorial mouths and are apterous. The Pediculidæ are parasitic on human beings and mammals, upon whom they may breed with great rapidity (partly by parthenogenesis), under favourable circumstances. The young louse is nearly perfect when first born — in fact these insects retain more or less their larval form throughout life. The three well-known species on human beings are the Head Louse (*Phthirius capitis*), the Clothes Louse (*P. vestimenti*), and the Body Louse (*P. inguinalis*). The species found on our domestic animals all belong to the genus *Hæmatopinus*. They are never found on the sheep or cat. The mouth is formed into a kind of sucking proboscis, which is plunged into the skin of the host.

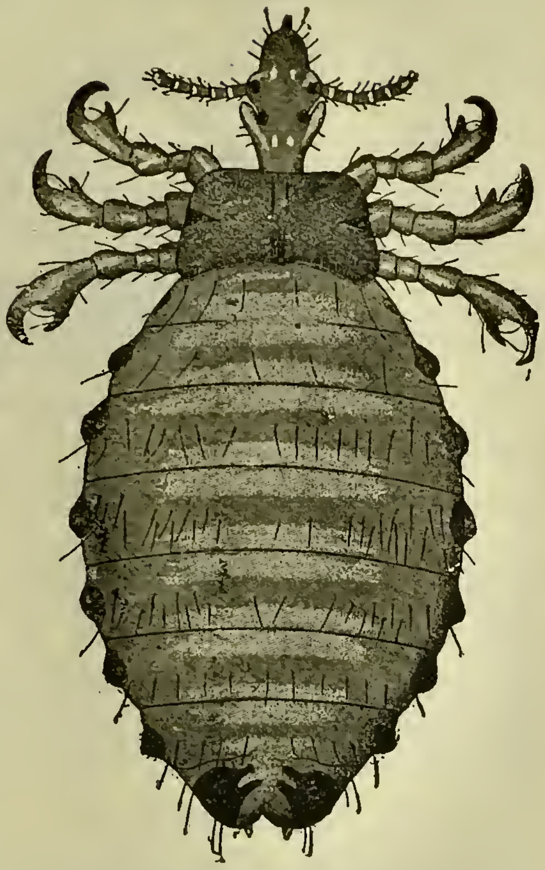
FIG. 160.—LOUSE OF THE OX (*Hæmatopinus eurysternus*), female. (Fleming.) Greatly enlarged.

ORDER ORTHOPTERA.

The Orthoptera are Earwigs, Cockroaches, Grasshoppers, Crickets, Locusts, Praying Mantis Flies, and Walking-stick Insects. They are characterised by having the anterior wings leathery in texture and narrower than the posterior ones, which are fan-shaped and large. The mouth of the Orthoptera is formed for biting. Many are provided with a curious "musical apparatus" (grasshoppers, &c.) There is usually a pair of long multiarticulate antennæ, and two large compound eyes as well as ocelli, on the head. The prothorax is freely movable. The metamorphosis may be very incomplete: in the most advanced we only get a semblance of larval and pupal stages, and some never pass the larval condition. Orthoptera have been divided into *Cursoria* or Runners, as the Cockroaches; *Gressoria* or Walkers, the Walking-stick Insects, &c.; and *Saltatoria* or Jumpers, the Grasshoppers and Locusts.[1]

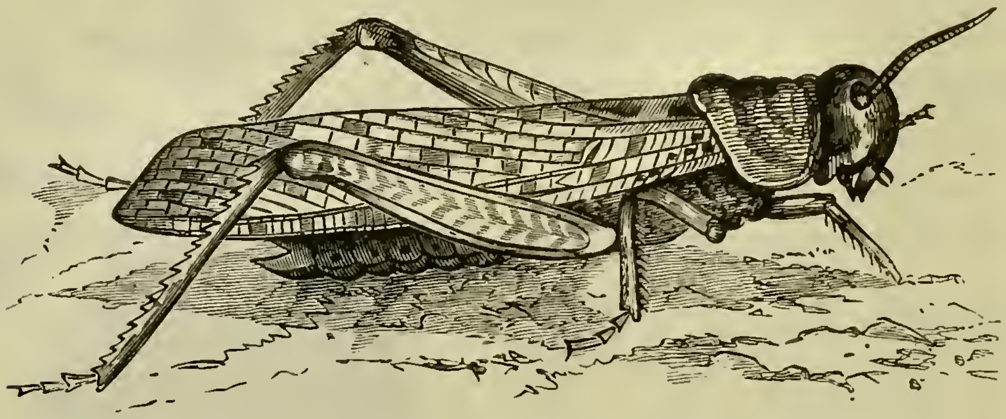

FIG. 161.—MIGRATORY LOCUST (*Ædipoda migratoria*). (Nicholson.)

EARWIGS (FORFICULIDÆ).

Amongst the Cursoria are the Earwigs (*Forficulidæ*), some of which are undoubtedly noxious insects. Earwigs are amongst our insect foes in the garden, and they have been too prevalent in the field, attacking crops of turnips, mangolds, cabbage, and hops. Early in the year the female comes from her winter quarters and lays her eggs in a hole in the ground and under stones. About twenty to thirty yellowish ova are laid together, and the female looks after the ova until they are incubated. I have found the eggs to hatch out in two weeks, but it is stated that they may take a month to incubate. The female looks after the young for some little time like a hen after her chicks.

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[1] Dr Sharp treats this order in two series—namely, *Cursoria*, including the Earwigs, Cockroaches, Mantis Flies, and Stick Insects; and *Saltatoria*, including the Locusts, Crickets, and Grasshoppers. The Earwigs are looked upon by some as a distinct order called *Dermaptera* or *Euplexaptera*.

The young are at first white, but become brown in a week, and have no signs of wings, but by degrees after several moults the wings appear. The common earwig (*Forficula auricularia*) becomes mature in July and August. Earwigs are mostly dark chestnut-brown or yellowish in colour, with dark eyes. The upper wings are very small, but the under pair are large, fan-shaped, membranous expansions, folded up in a most remarkable way beneath the small scale-like upper ones. This species seldom uses its wings, although I have taken them on the wing.[1] The small Earwigs (*Labia minor*), on the other hand, fly about in the sunshine. *Forficula auricularia* feeds only of a night, and hides away beneath the earth and stones during the daytime and under the bark of trees, &c. They strip the blossoms of plants, and have now and again done much damage to hops.

Prevention and Remedies.—Trapping is the best way to get rid of these pests. Heaps of straw put about in the hop-gardens and fields, and burnt in the daytime, will get rid of hundreds. Pieces of sacking laid about on the ground will be found to entice great numbers. In Germany old baskets are put up on sticks full of some rubbish to attract the earwigs, and then destroyed. During an attack on the South-Eastern Agricultural College hops in 1896, soot placed round the hills was found most efficacious, driving the pests away and enabling the hops to recover from their damage. Catching over tarred boards of a night is also an excellent way in hop infestation.

COCKROACHES (BLATTIDÆ).

Several so-called "Black-beetles" are found in England, and are often destructive. The three commonest species are the Common Black Beetle (*Blatta orientalis*), which is dark chestnut-brown; *Periplaneta americana*, or the American Cockroach, a much larger species, often an inch and three-quarters long, with a yellowish thorax with chestnut-brown markings, chestnut-brown wings, and the antennæ very long. The third species is called the German Cockroach (*P. germanica*), and is a small yellowish-brown species, with two dark-brown stripes on the thorax. Another species, *P. australasiæ*, is also found doing some harm in conservatories. The Black species (*B. orientalis*) is only winged in the male, the others in both sexes. The eggs are laid in packets, and sometimes, as in *P. germanica*, are carried about by the female.

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[1] Ento. Mo. Mag., p. 61, 1896.

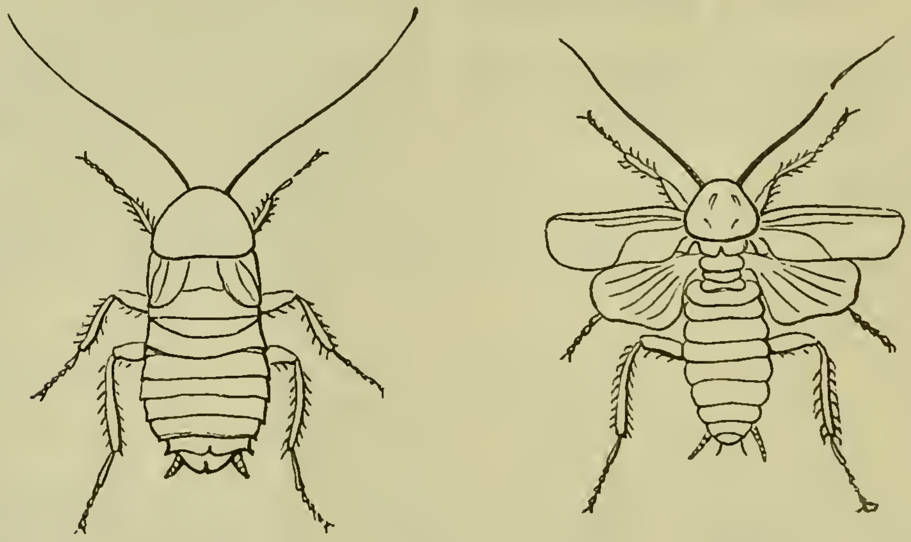

FIG. 162.—FEMALE AND MALE COMMON COCKROACH (*Blatta orientalis*). (Nicholson.)

The young are all pale-coloured, and occasionally almost white when they have just changed their skin.

Prevention and Remedies.—Persian insect-powder, spread about where these pests are, is a good remedy; but trapping keeps them well in hand, whilst a hedgehog will speedily clear them out from the basements of houses. Voss's phospho-nicotyl is also an excellent remedy.

It is not necessary to refer to the Locusts, Grasshoppers, and other Orthoptera, as they are seldom destructive in England.

The Mole Cricket (*Gryllotalpa vulgaris*) (fig. 163) is sometimes an unpleasant insect in gardens and greenhouses, burrowing in the soil, but is nowhere very plentiful, except in the Channel Islands.

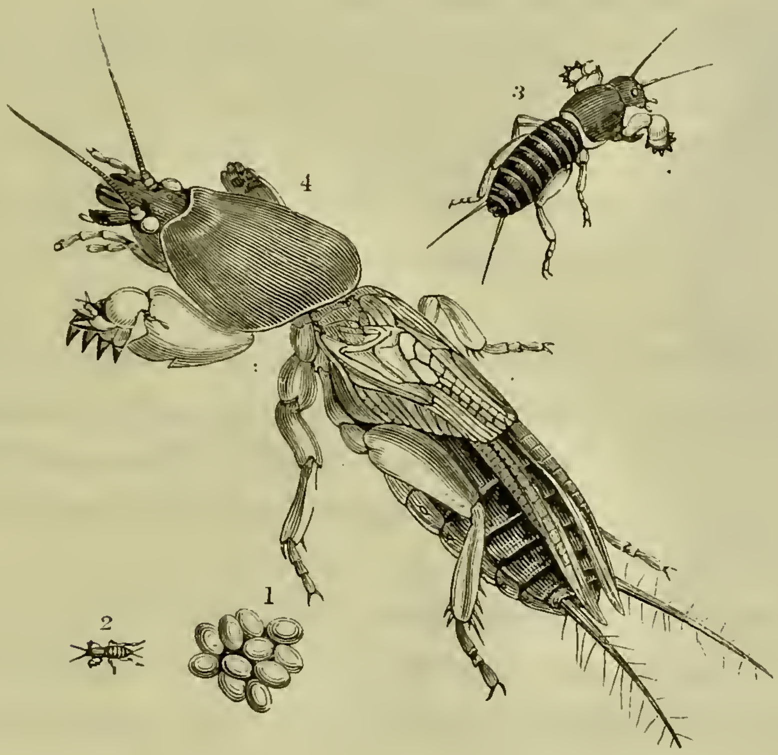

FIG. 163.—MOLE CRICKET (*Gryllotalpa vulgaris*), 4.
1, Ova; 2 and 3, young crickets. (Curtis.)

NEUROPTERA.

In this order are grouped many diverse forms. Some insects now included were at one time classified as distinct orders, but without sufficient grounds, and hence are now incorporated in this one group. As a rule, Neuroptera may be said to have four wings of the same texture, with numerous veins and cross-veins, giving them a peculiar lace-like or reticulate appearance. If we include here the Ant-lions, &c., complete as well as incomplete metamorphosis is found. Many are aquatic in the larval stage. The Neuroptera include the

Dragon-flies, May-flies, Lace-wings, Scorpion-flies, Ant-lions, Stone-flies, Termites, &c. The Bird-lice, *Mallophaga*, wingless parasites, also belong to this order.

The Neuroptera are grouped in five divisions and eleven families, as follows:—

1. **Trichoptera.**—No mandibles in adults. The wings develop internally, becoming evident when the pupal form is attained. Larvæ and pupæ aquatic. Family *Phryganeidæ* (Caddis-flies).

2. **Neuroptera planipenna.** — Adults always mandibulate. Some are aquatic, others terrestrial during the early stages. Development as in Trichoptera. Families *Panorpidæ* (Scorpion-flies), *Sialidæ* (Snake- and Alder-flies), *Hemerobiidæ* (Lace-wings and Ant-lions).

3. **Neuroptera amphibiotica.**—Wings develop prominently outside the body. Aquatic larvæ and pupæ. Families *Odonata* (Dragon-flies), *Perlidæ* (Stone-flies), and *Ephemeridæ* (May-flies).

4. **Pseudo-neuroptera.**—Wings develop as above. No definite pupa. Entirely terrestrial. Families *Termitidæ* (White Ants), *Psocidæ* (Book-lice), and *Embiidæ.*

5. **Mallophaga.**—Wingless and parasitic.

Bird-lice (Mallophaga).

Birds are subject to a number of lice: these lice are called Mallophaga, and are included in the order Neuroptera. They are all apterous, and provided with a biting mouth, taking their nourishment from the epidermal products of the skin. The ova are laid on the host; the larvæ are like the adult, only paler in colour — in fact, metamorphosis is very slight, the young gradually getting darker in colour as they grow older. There is one genus (*Trichodectes*) (fig. 164) found on mammals, such as the Horse, Ox, and Sheep Louse, &c., and sometimes these cause severe pruritus. This genus, as seen in the dog, may serve as a host for one of the Tapeworms that infests the dog. The Bird-lice are often very injurious to poultry: four genera are common on fowls and chicks, namely, *Goniodes*, *Goniocotes*, *Menopon*, and *Lipeurus.* These lice live upon the birds permanently, — Goniodes and Goniocotes on the neck, under the wings, and on the rump. Menopon is more active, and wanders over the whole body: this is the louse that crawls on to a person plucking fowls, but soon dies. Lipeurus lives between the barbs of the wing-feathers. These lice eat away at the base of the feathers, the skin, &c., and cause severe irritation. They stunt the growth of young chicks to a serious extent, and prevent the birds taking nourishment and rest.

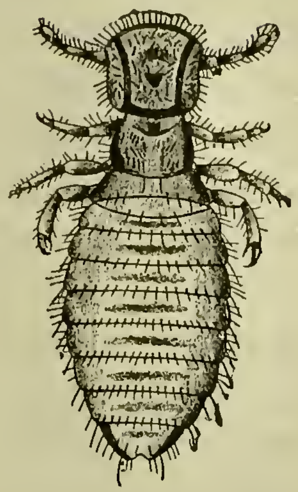

FIG. 164.—TRICHODECTES SPHÆROCEPHALUS (♀) OF SHEEP, mag. 20 diameters. (Fleming.)

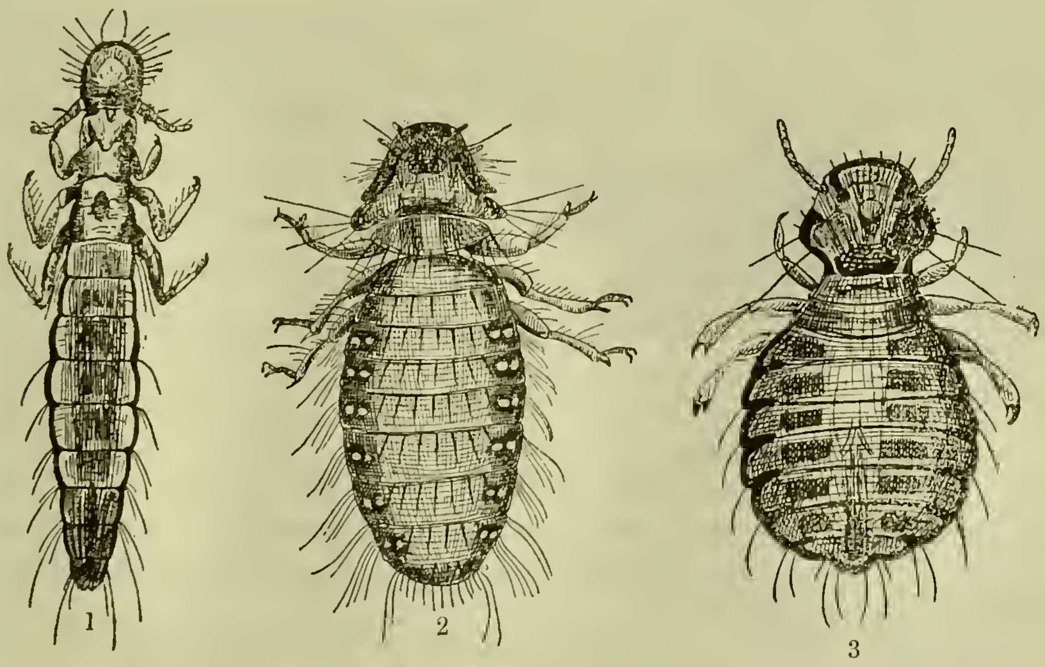

FIG. 165.—MALLOPHAGA OR BIRD-LICE.

1, *Lipeurus variabilis.* 2, *Menopon pallidum.* 3, *Goniocotes hologaster.*
(All greatly enlarged.)

One can usually detect the presence of lice on birds by the barbs of the feathers, especially those of the saddle-hackle, becoming notched and jagged. The antennæ of the Bird-lice are composed of four or five joints; those that we get on the mammalia (*Trichodectes*) have three-jointed antennæ. These must not be confounded with the piercing-mouthed lice (*Hæmatopinus*).

Prevention and Treatment.—All fowls should have "dust-baths," so that they can rid themselves of these pests. Road dust and lime or gypsum and a little paraffin make as good a mixture as any. All brood-hens should be dressed around the rump and under the wings with mercurial ointment before being set, and young chicks should be similarly dressed up the neck to kill the tick-like species (*G. Eynsfordii*) which stunts their growth so seriously.

LACE-WING FLIES (HEMEROBIIDÆ).

Lace-wing flies are of much service to us as a natural enemy of plant-lice. They are beautiful Neuroptera, with clear lace-like wings, bright shiny golden eyes, and green or yellowish-green bodies. Some have the power of giving forth a very offensive smell when touched. The eggs of the "Golden Eye" are peculiar structures, laid on long stalks (fig. 166, C) in groups upon the leaves of plants and trees. The larvæ (A) are provided with a powerful sickle-shaped pair of jaws, by means of which they ravenously devour the Dolphins; and having sucked out their life-juices, they throw the empty skins over their back to form a protection against the prying eyes of birds. Beneath this curious Periclean covering the larva pupates. The larvæ are often called Aphis Lions. A number of different species exist.

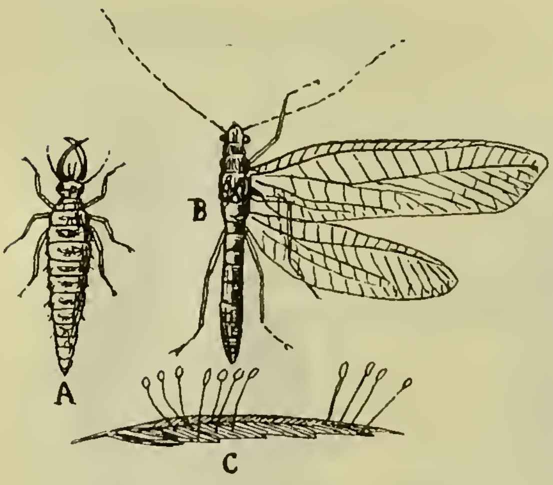

FIG. 166.—LACE-WING FLY.

A, Larva, or Aphis Lion (enlarged); B, adult; C, ova (reduced).

CADDIS-FLIES (PHRYGANEIDÆ).

Caddis-flies, Water-moths, or *Trichoptera*, are Neuroptera that are aquatic during their larval life. The adults resemble moths in appearance; but the wings are not scaly, and are turned down at the sides of the body when at rest. They are more or less covered with hairs, and the cross-veins are much fewer than in most Neuroptera; legs and antennæ are long, and their mouth-parts are but poorly developed. The eggs are laid in gelatinous masses upon water-plants. The larvæ, which are often extremely injurious to water-cress, live in curious cases made up of stones, shells, pieces of wood, &c. The Caddis-worms are long cylindrical larvæ with scaly heads and strong jaws; the three segments near the head are leathery, and each bears a pair of legs. The front part of the larva alone sticks out of the case when moving, the other nine segments being enclosed in the curious larval covering. The tail has two hooks by which the insect anchors itself to a stone or plant in the water. Some species reach nearly an inch in length. The pupal stage is passed in the case, the pupa emerging a short time previous to the advent of the adult, and crawling up to the surface of the water, ready to escape. There are a great number of species; but the most abundant in the water-cress beds is *Limnephilus flavicornis*, which has a wing-expanse of one and a quarter inch.

Prevention and Remedies consist in draining off the beds and clearing out all the plants, leaving the beds to dry for some weeks previous to winter planting. Birds, especially sparrows, clear the insects off, and do much good. When present in numbers, a good plan is to fill the beds full of water and move the tops of the plants about with poles and rakes to shake the worms off: they then float to the top, and are run off with the excess of water.

DRAGON-FLIES (ODONATA).

The Dragon-flies are all carnivorous, feeding off butterflies and moths and other insects when adult, and upon various water insects when in the larval stage. They are often called Sketer Hawks, because they devour the aquatic mosquito larvæ. The adults have large eyes, these often occupying the greater

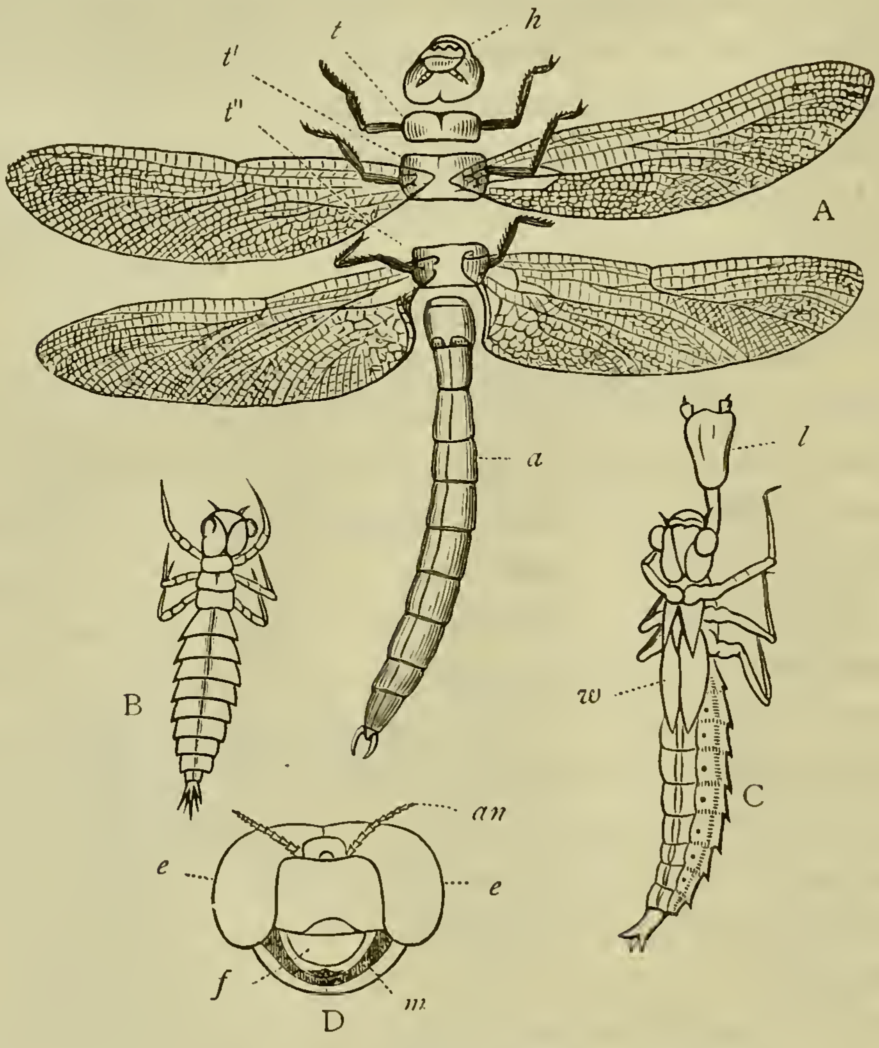

FIG. 167.—DRAGON-FLIES.

A, A Dragon-fly (*Æschna grandis*), partly dissected; B, larva; C, pupa; D, head of *Libellula depressa*. *h*, Head; *t* to *t″*, thoracic segments; *a*, abdomen; *an*, antennæ; *e*, *e*, eyes; *m*, jaws; *f*, upper lip. (Nicholson.)

part of the head. They are provided with very powerful mouths. Their wings are usually transparent, and have a number of mesh-like veins. The legs have a series of spines upon them. Dragon-flies are most useful as insect destroyers. Each individual seems to have a hunting-ground of its own, either over a piece of water, along some lane, or in some glade in a wood. There are some (*Libellulidæ*) which are beautiful fragile insects (*Calepteryx*). The eggs are laid in the water or on aquatic plants. The young (fig. 167, B) possess no traces of wings. They commence to show after the third or fourth moult (C, *w*). The nymph (C) has a much shorter body than the adult, and, previous to hatching, crawls up the stem of some water-plant, when the shell splits, and the perfect Dragon-fly emerges.

APTERA.

Lastly, we have the wingless primitive insects, the *Collembola* and *Thysanura*, now united into one order, the *Aptera*. Many are popularly called "Spring-tails." There are never any wings or rudiments of such, but always three pairs of legs, and long or moderately long antennæ. They practically remain in the larval stage throughout life. The *Thysanura* have ten segments in the abdomen; the *Collembola* have six or less segments, and the first one is always provided ventrally with a curious tube, which is absent in the *Thysanura*. The *Collembola* have the power of leaping or skipping into the air: some have a long, forked, ventral process towards the anus, which is used as a leaping apparatus.

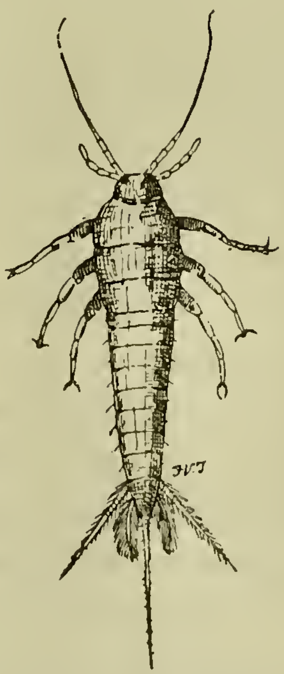

Fig. 168.—Silver Fish (*Lepisma saccharina*).

Collembola are often injurious to seedling plants (*Achorutes* *armatus*, &c.), to mushrooms (*A. rufescens*), to fruit bushes (*Sminthurus luteus*, &c.); and a few *Thysanura* are more or less noxious, as the Silver Fish (*Lepisma saccharina*) (fig. 168), a curious silvery form found in books and in houses generally.

CHAPTER IX.

MOLLUSCA.

THE Mollusca form a large class of animals, to which belong Snails, Slugs, Oysters, Cockles, Mussels, Octopi, and Sepias, as well as many extinct forms, such as Ammonites.

Mollusca are generally provided with a shell formed by part of the animal known as the mantle: this shell is nearly always external, but in some few it is buried under the skin (Slugs). All mollusca are unsegmented animals, and bilaterally symmetrical in the young or embryo stage. The bilateral symmetry soon goes in the adult, and they are often much contorted, especially those that lie in a spiral shell. The skin of Mollusca has peculiar characteristics: one particular part—the so-called "mantle" that lines the shell—has the power of secreting calcareous salts which go to make up the shell. This mantle forms a cavity in the mollusc, the so-called "mantle cavity" or "respiratory sac." Some molluscs (Snails, &c.) have a pulmonary sac, and live upon land, breathing air; others (Mussels, Oysters, &c.) have gills or branchiæ, which are bathed with the water in which they live. Most Mollusca are aquatic—the majority marine, a few fresh-water; and some are amphibious; and there are numerous terrestrial species, but the land genera are few. Internally Mollusca are provided with a distinct heart and alimentary canal, the former consisting of two auricles and one ventricle, the ventricle traversing the two auricles; both are surrounded by a membrane, the pericardium. From each end of the ventricle a tube runs off to the anterior and posterior end of the body. The blood is colourless or pale yellow or pale green, and consists of amœboid corpuscles only. The nutritive substances derived from the food in the digestive tube pass through the walls of the tube and mix with the blood in the neighbouring vessels. There are no lymphatics as in vertebrate animals. A large muscular area used for locomotion is found in most groups, called the "foot" (fig. 169, *f*). This structure is much modified according to its function: in some it is used for boring, in others for crawling, and yet others use it for leaping. There are two chief types of shells formed by these invertebrates—Bivalve (fig. 171) and Univalve (fig. 173) shells: the former consist of two valves united by an area called the hinge-line; the other may be a simple tube, a spirally coiled tube, or a conical flattened disc.

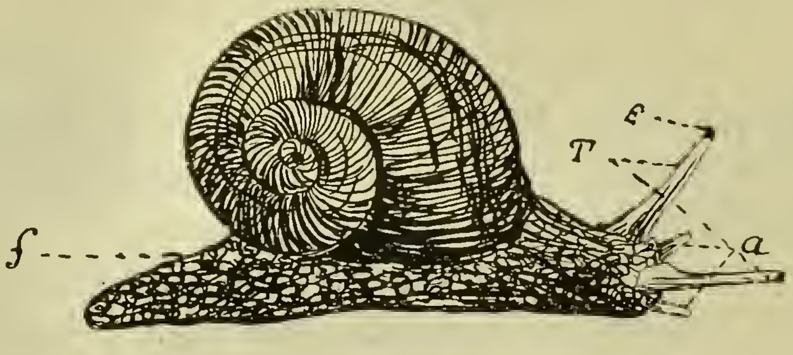

FIG. 169.—EDIBLE SNAIL (*Helix pomatia*).

T, tentacles; *E*, eyes; *a*, small tentacles; *f*, foot. (Brit. Mus. Guide.)

Reproduction in Mollusca is sexual: both the sexual organs may be in the same individual or in separate individuals. The former (hermaphrodites), nevertheless, reproduce by cross-fertilisation. The majority of land Mollusca develop direct; but in many aquatic species there is a larval form.

In *Unio* or the Fresh-water Mussel the ovaries and testes—the female and male genital glands—are found in the foot. They are in separate individuals (diœcious). They are large in winter and spring, as the breeding season is then on. The male cells, spermatozoa, are discharged into the water with a milky fluid, and chance being swept into a female Unio. There is no external sexual distinction between a male and female mollusc. The genital glands are branched structures, consisting of a gland on each side of the middle line of the body. The tubes of these glands are lined by a layer of specially modified cells, epithelial cells, which develop into either ova or spermatozoa as the case may be. The tailed spermatozoa fertilise the ova in the mantle cavity of the female. One female Unio may produce as many as 3,000,000 ova in a season. The ova collect between the gill lamellæ, where they undergo development, and here appear the young larval Unios, which are known as *Glochidium* larvæ. They eventually leave the parent and become attached to fish and other objects, upon which they finish their development, when they relinquish their hold and sink to the bottom of the water, where the Glochidium becomes the adult Unio. Excretory organs are present, as the organs of Bojanus, acting as kidneys in function, and connected with the pericardium as well as the exterior.

Mollusca have a distinct nervous system, typically composed of three pairs of ganglia connected by commissures, each pair forming a kind of nerve-centre. Some Mollusca have eyes, as seen in Pectens and Helix (fig. 169, *E*), whilst auditory organs are also found (otoliths).

The Mollusca are divided into four groups—namely:

1. Lamellibranchiata.
2. Gasteropoda.
3. Cephalopoda.
4. Pteropoda.

These are divided into two sections—

A. Acephala (headless molluscs) = Lamellibranchiata (Mussels, &c.), or bivalves.

B. Encephala (headed molluscs), or univalves and multivalves.

The Encephala are provided with a curious masticatory apparatus called the "odontophore": one part is a ribbon-like mass of teeth (fig. 170) which can be drawn in and out, called the *radula*, and which is used by snails and slugs in devouring the vegetation. The only group with which we need deal here is that of the *Gasteropoda*, as they alone are of any agricultural importance. The others, however, may be briefly referred to, as completing the series of the animal kingdom.

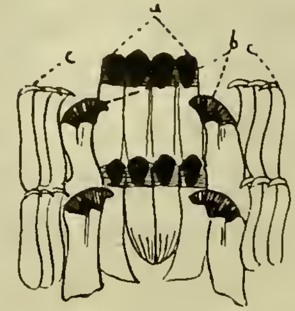

Fig. 170.—Two transverse series of teeth from radula of Limpet. Much enlarged. (Brit. Mus. Guide.)

Lamellibranchiata. — These are all bivalve headless Mollusca, whose mantle consists of two distinct flaps, each of which secretes one of the valves. They respire by gills placed in the cavity formed by the two halves of this mantle. The cavity so formed communicates (in one division) by a siphon with the exterior (*Siphonata*). Bivalve shells with the line marked on the inside of the shell —the pallial line, indented (fig. 171, *c*)—can at once be distinguished as siphonate forms. Those that have no pallial sinus are asiphonate forms (fig. 171, 3). The foot is generally a large, wedge-shaped, muscular body. Most are marine, but some—such as *Unio* and *Anodonta*, Fresh-water Mussels—live in our rivers and ponds. To this class Oysters (*Ostrea*), Mussels (*Mytilus*), &c., belong.

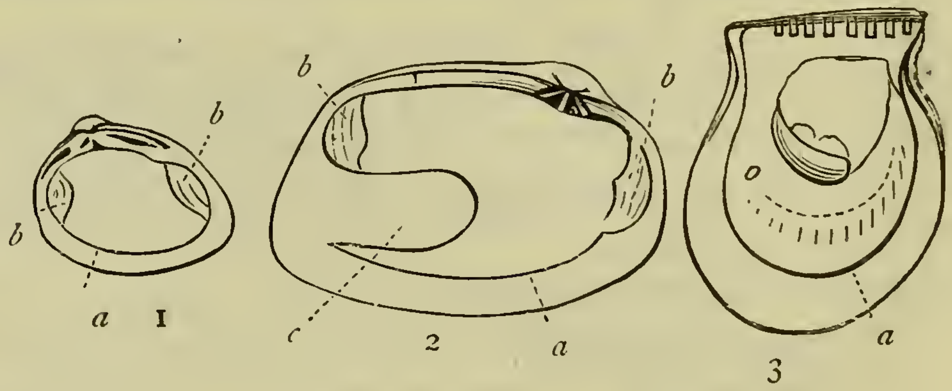

Fig. 171.—Shells of Lamellibranchs.

1, *Cyclas*, with two muscle scars (*b b*) and entire pallial line (*a*); 2, *Tapes*, with indented pallial line (*c*); 3, *Perna*, with one muscle scar and complete pallial line (*a*). (Nicholson.)

Cephalopoda.—The Cephalopoda are the Cuttlefish, Nautilus, Squid, &c. In these we find a distinct head, and the mouth is surrounded by a circle of arms which bear numbers of suckers. The arms are divisions of the foot. These molluscs, many of which have an internal shell (*Sepia, Loligo*), are carnivorous

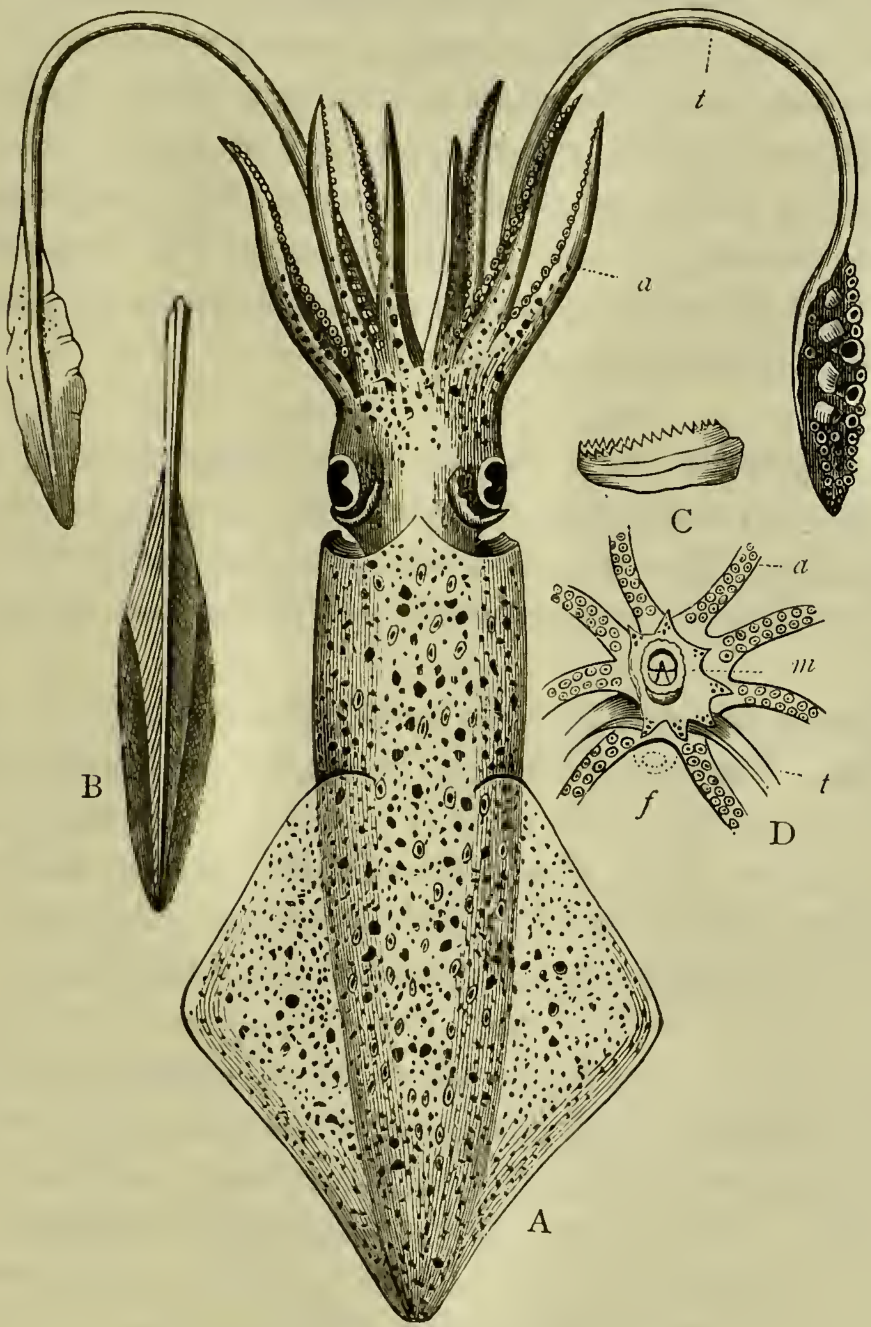

Fig. 172.—Common Calamary.

A, A Cephalopod (*Loligo vulgaris*); *a*, ordinary tentacle; *t*, long tentacle. B, internal shell. C, side view of one of the suckers. D, front view of head; *a*, bases of arms; *t*, tentacles; *m*, mouth; *f*, funnel. (Nicholson.)

marine animals (fig. 172). Some have a curious organ called an "ink-bag," which contains a brown fluid, "sepia": this fluid the mollusc ejects when pursuing its prey so as to confuse it, and likewise to hide itself when being pursued by its enemies. The Nautilus has a complete external shell, quite unlike the "cuttle-bones" given to birds, the internal shell of Sepia. The sexes are separate, and some remarkable ways of reproduction exist (hectocotylisation), but such subjects are outside our province. Many fossil forms are found, as the *Ammonites* and *Belemnites* of the Lias, Gault, and Chalk, &c.

The **Pteropoda** are a small class of free-swimming pelagic Mollusca provided with two wing-like appendages and with glassy shells. They are carnivorous, feeding mainly upon crustacea, and they in their turn form part of the food of whales.

Gasteropoda.—Gasteropods include the majority of univalve Mollusca. They are found in the sea, in fresh-water, and on land. The foot is in the form of a broad, flat, ventral mass, or may be in the shape of a curious fin-like organ. Gasteropods have never a bivalve shell—the shell is either univalve or multivalve. The simplest type of shell is seen in the limpet. They are often coiled or "whorled" (fig. 173); each division of the spire or whorl may be in contact or widely separate; the mouth is either round or oval, slit-like in a few genera (*Cypræa*), and bordered by the rounded "lips." A column or pillar runs up the centre of the spiral shells, forming the *columella*. The body of a Gasteropod is divided into head, foot, and visceral sac; the last is enclosed in the mantle, which is never divided into two lobes as in bivalves. Most Gasteropods have an unsymmetrical body, coiled spirally, the respiratory organs of the left side being atrophied. The flattened foot may secrete a horny or calcareous plate, the *operculum*, which serves to close the orifice of the shell when required. The head is distinct, with two tentacles, and two eyes often placed upon long stalks. A proboscis is sometimes present, having at its base the ear-sacs containing the "ear-stones" or otoliths. The "radula" is always well developed: this ribbon-like mass of teeth is composed of chitin (fig. 170). Some families breathe air (*Pulmonata*); the majority are aquatic, chiefly marine. In those that live in water we find three types of respiration—(i) Where there are no special respiratory organs, the blood simply being bathed by the water in the mantle cavity; (ii) another type is seen in the "nudibranch gasteropods," which have gills on their back; and (iii) those which have gills in the mantle cavity (*Haliotis* or Ear-shells, &c.) The sexes are for the most part distinct (diœcious); but Snails (*Helicidæ*) and Slugs (*Limacidæ*), &c., are hermaphrodite. The young when first developed have always an embryonic shell. Many marine species develop by a metamorphosis,—the larva being "nautiloid" in form, with a ciliated expansion called the "velum." Terrestrial forms have no metamorphosis, but develop direct. A young snail is much like a fully developed snail, save for its smaller size and more transparent shell.

The Gasteropods that we are interested in all belong to the group *Pulmonata*, in which a shell is generally present and respiration is aërial, the deflected mantle forming a pulmonary chamber.

Mollusca injurious to our crops belong to the two families known as *Helicidæ* (Snails) and *Limacidæ* (Slugs), both terrestrial in habits. A third family of economic importance are the *Limnæidæ* or Water-snails.

LIMNÆIDÆ, OR WATER-SNAILS.

These aquatic or semi-aquatic molluscs are the hosts of the liver-flukes in various parts of the world. They are found at all elevations, on mountain-sides as well as in damp fenny countries. Water-snails are hermaphrodites, and frequent shallow and still waters and damp meadows; many may often be found together, and they are most prolific. One may find them at all times of the year. The shells are elongated and conically oval, the spire being produced, while the snail's body is twisted up in the spire of the shell. They have a prominent head and an oblong foot, notched in front and rounded behind. The shells are extremely variable, one species (*Limnæus pereger*) having at least fourteen varieties. In this country the two species important to us are *L. truncatulus* and *L. pereger*. Both are hosts of the all-important liver-fluke (*Distomum hepaticum*) which causes the "liver-rot" in sheep.

L. truncatulus (fig. 173, A) is a pale ashy-grey turreted shell with five or six whorls, the last whorl being large and expanded, and occupying about three-fifths of the shell; the spire tapers to a very fine point. It is found nearly all over Britain and Europe, Afghanistan, Morocco, Algeria, the Canary Islands, &c. This snail lays its ova or spawn upon mud around ponds, ditches, and streams. Each snail lays about 1500 ova, in batches of 30 to 100. They are deposited in strips of some gelatinous substance. Incubation takes place in about two weeks. This is the chief host of the liver-fluke.

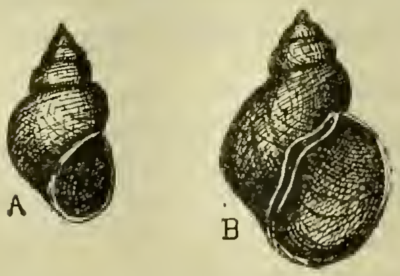

FIG. 173.—WATER-SNAILS (*Limnæidæ*).

A, *Limnæus truncatulus*; B, *L. pereger*. Twice nat. size.

L. pereger (fig. 173, B), the other fresh-water snail, is almost transparent yellowish-brown, and spirally striate, with five whorls. This species often wanders far from water, and may be found crawling up willow-trees and in damp meadows. They are carnivorous in habits. Although the embryos of the liver-fluke are found in this species, it seems it cannot complete its changes in it. Were there no Limnæidæ there would be no liver-rot in our flocks; but it is extremely difficult to destroy these molluscs. There is no doubt that the suggestion made by Miss Ormerod of clearing out shallow pools of weeds, and removing the broad growth of weeds and mud from the entrance of pools where sheep may water, would do much good where practicable. The destruction of the snails by putting gas-lime or lime and strong salt over the mud when cleared out of the dykes and ditches would greatly lessen the evil.

In N. America *L. humilis*, and in S. America *L. viator*, probably serve as hosts for the liver-fluke.

SLUGS (LIMACIDÆ) AND SNAILS (HELICIDÆ).

Slugs and Snails are often a great pest to the farmer and gardener. Now and then a plague of one or the other may ruin our field-crops. These possess a head which bears tentacles, and also a pair of eyes which may be on long stalks. The foot is flat, and the rasping tongue or "radula" is well developed. Both Snails and Slugs are hermaphrodites. The eggs are laid in batches in the ground and under stones and rubbish.

The slugs have only a rudimentary shell or an indefinitely formed one under the mantle. Slugs mostly frequent damp places, and bury themselves during the daytime in the earth. The eggs are laid singly, but in groups, in the ground, and are very numerous. The chief genera are known as *Arion*, *Limax*, and *Agriolimax*. *Arion* can be told by having the slime-gland in the posterior extremity, and the respiratory orifice in front of the shield-like shell. The *Arions* feed at night upon the tenderest and choicest plants, but they will devour anything at times. The *Limaces* are especially fond of indoor life. All slugs excrete a thick slime, and this can be exuded at least twice in rapid succession, a character which we may well remember when we are trying to destroy them.

The most destructive slugs are *Agriolimax agrestis*, *L. maximus*, *Arion ater*, and *A. hortensis*.

The *Grey Field-slug* (*A. agrestis*) (fig. 174) is by far the most injurious land mollusc. It may be found in most gardens and fields in Britain. Like all slugs, its life is dependent on moisture. In dry weather it gets under stones, &c., and comes out only at night to feed. The body is spindle-shaped and ashy-grey in hue, with a reddish or yellowish tinge, sometimes mottled; the foot has pale sides, and the shield is large. The oval shell is very thin, and marked with indistinct lines of growth with a broad membranous margin. It exudes great quantities of slime, and is most prolific. Seven or eight separate batches of fifty ova each are laid during the breeding season, which is from May to November. The little ova are laid in heaps of six to fifteen in the ground and under moss, especially during August, September, and October. They take three weeks to develop; the adults live many years. In the winter they may be found under stones and rubbish in a semi-torpid state. All kinds of plants are more or less attacked by them. It is chiefly in damp weather that slugs are destructive.

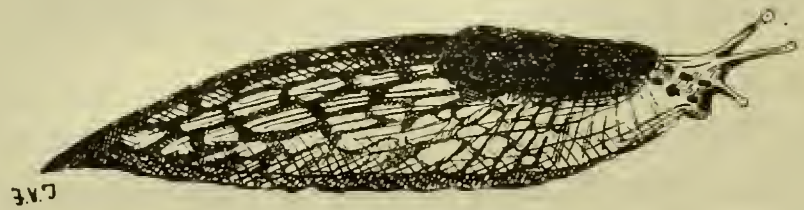

FIG. 174.—GREY FIELD-SLUG (*Agriolimax agrestis*). Slightly enlarged.

Another species is the Black-striped Slug (*L. maximus*), which sometimes reaches seven inches in length. Although not very prolific, it does much harm. The ova are deposited in heaps, joined together with a gummy slime, during the autumn. These slugs vary much in colour: some are black, others yellowish, spotted with black and white; the foot is always edged with white, and the slime is always iridescent when dry, white when fresh.

The common Black Slug (*Arion ater*) is about four inches long. It varies from black to red, yellow, dark-green, or brown, and is covered with prominent tubercles, much contracted in front and pointed behind; the foot has a yellowish border, and the slime is also yellowish. The shell consists of a number of small separate calcareous grains. This species is a scavenger as well as being injurious.

Another curious group of Slugs belong to the genus *Testacella*. These molluscs (fig. 175), of which there are three species in England (*T. haliotidea*, *T. scutulum*, and *T. maugei*), feed almost entirely on earthworms, slugs, snails, millepedes, &c. The Testacellæ are the only true predaceous or carnivorous land mollusca. They hunt earthworms in their burrows, and devour huge lobworms much larger than themselves. The mouth is furnished with long curved teeth (T), so as to hold the victim. They live for four or five years. The eggs are laid separately in April, and resemble hen's eggs in shape, and covered by creamy white calcareous shells. From six to twenty ova are laid by *T. haliotidea*. According to Collinge, they hatch in from fourteen to seventeen days.

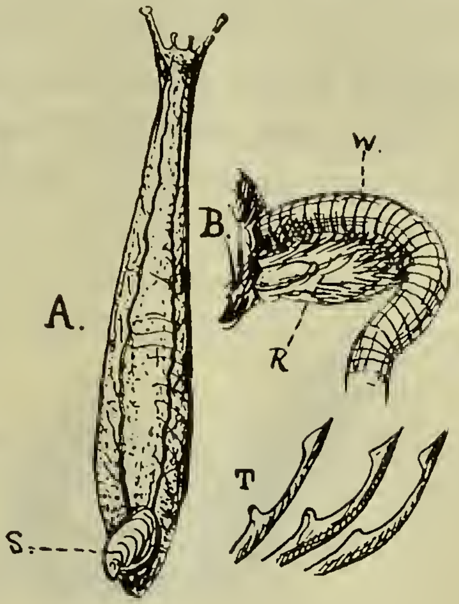

Fig. 175.—Testacella.

A, *Testacella haliotidea:* B, head; R, radula; W, worm; T, teeth from radula.

Snails (Helicidæ).

The Snails, like Slugs, are nocturnal and crepuscular, seldom crawling about in the daytime, unless after heavy rains. The latter habit has given rise to a popular idea that snails come in rain-clouds. When the breeding season is on, the male organs are supplemented by one or more curious crystalline darts, which they thrust out at one another: these curious structures, found in special sacs called "dart-sacs," are peculiar to the genus *Helix*. The eggs are laid in batches in slanting galleries underground formed by the "mother" snail: they are white, round, semi-transparent bodies.

The following snails have been brought to the author's notice as being very injurious: The Garden Snail (*Helix aspersa*), the Wood Snail (*H. nemoralis*), the Strawberry Snail (*Hygromyia rufescens*), *H. virgata*, and *H. caperata*, which migrate from the Downs to the fields in numbers at certain times.

The Garden Snail (*H. aspersa*), fig. 176, is one of the commonest and most easily obtainable. This large species needs no description, as it is well known in every garden. The ova are laid in heaps of sixty to seventy in the earth; they are white, shining, globular bodies, which hatch out in fifteen days if kept in the damp. The young are almost colourless, the shell being thin and transparent. Drought and cold are erroneously considered harmful to snails. At the approach of winter they collect together, and exude a slimy matter which hardens and closes the aperture of the shell. This covering or lid is called the epiphragm, and must not be mistaken for a permanent operculum. The common snail may be found hibernating together in crevices in walls, in old trees, and under rubbish, united together by the agglutinated slime.

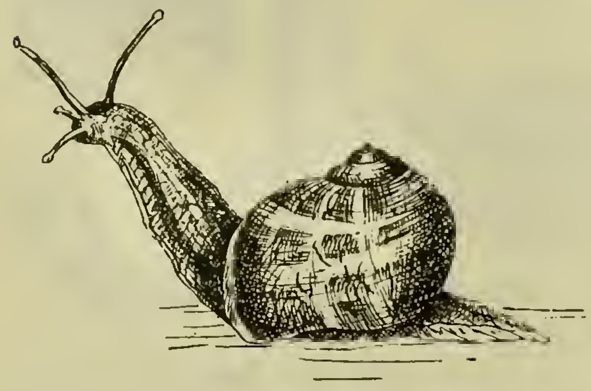
FIG. 176.—GARDEN SNAIL (*Helix aspersa*). Reduced ½.

H. nemoralis, or the Wood Snail, is abundant in hedgerows and upland pastures, especially clover, where it often does much damage. *Hygromyia rufescens*, the Strawberry Snail, often does much damage to strawberries.

In destroying slugs, we must bear in mind the fact that they exude a thick slime which retains any poisonous substance we may put over them, and which they can cast off. They cannot, however, repeat the violent excretion of the repellent substance more than twice, so that three dressings at short intervals are necessary before we can reach the slug's skin to destroy it with such substances as soot, salt, and lime. Unless this is done, time and money are simply wasted. I have seen slugs sitting quietly on lime, surrounded by their slime, and in no ways affected. Again, we must note they only come out at dusk, or after rain, or in damp weather; evening and early morning are then the times to attack them, and more especially so in dry weather. The various soil fumigants, such as vaporite, fumite, and apterite, readily destroy slugs. Hydro-oxide of calcium in a one to two per cent solution in water is also an excellent remedy.

Both Snails and Slugs have many natural enemies, such as ducks, fowls, rooks, starlings, blackbirds, and thrushes. The last two are of great assistance in keeping down an excess of Helices. Moles, shrews, and toads also eat them.

Those who wish to pursue this subject further are referred to the two following papers: "Injurious Mollusca," 'The Zoologist,' p. 201, June 1895; and "Injurious and Beneficial Slugs and Snails," 'Journal of the Board of Agriculture,' vol. xi. pp. 594-602 and pp. 650-658. 1905.

PART II.

CHORDATA (VERTEBRATA)

CHAPTER X.

CHORDATA.

TUNICATES OR SEA-SQUIRTS AND AMPHIOXUS = ACRANIA.

THE Mollusca form the last true invertebrate group. Between the invertebrates with their ventral nervous system and dorsal hæmal system and the true vertebrates with their dorsal nervous system and ventral hæmal system and skeleton there are connecting-links—namely, the group of *Ascidians*, *Tunicates*, or Sea-squirts; a worm-like creature known as *Balanoglossus;* and a stage further, connecting these with the true definite vertebrate animals, the little Lancelet, *Amphioxus lanceolatum*, a fish-like creature found in the sands of the Mediterranean and in Japan. These are called, collectively with the true Vertebrata, by some zoologists **Chordata**. The Chordata are divided into two sections—viz., (1) *Acrania* and (2) *Craniota*. The curious types we refer to here belong to the former section. *Amphioxus* is undoubtedly a vertebrate animal; although it possesses no vertebræ, no true internal skeleton, yet, as we shall see, it has a dorsal nervous system, and that structure peculiar to chordate or vertebrate animals—namely, the notochord, which becomes less and less recognisable the higher we proceed in the vertebrate scale, until it is only represented as mere pads between the vertebræ in the Mammalia.

Tunicates (figs. 177, 178) or Sea-squirts are flask- or bottle-shaped gelatinous-looking masses found attached to rocks, &c., in the sea. That they constitute an important group we can readily understand when a monograph of the forms found by the Challenger expedition reaches eight hundred odd quarto pages. Such subjects are outside our province, as they are purely marine animals. It is sufficient for our purpose to point out that these Sea-squirts, which in their adult form are undoubtedly invertebrate in type, are in their larval or early stages distinctly vertebrate. The so-called *Appendicularia* larva (fig. 178, A) has a distinct dorsal skeletal rod, the notochord (*g*), in its tail, which entirely disappears in the adult,—the dorsal nervous system becoming ventral by a curious and complicated series of changes.

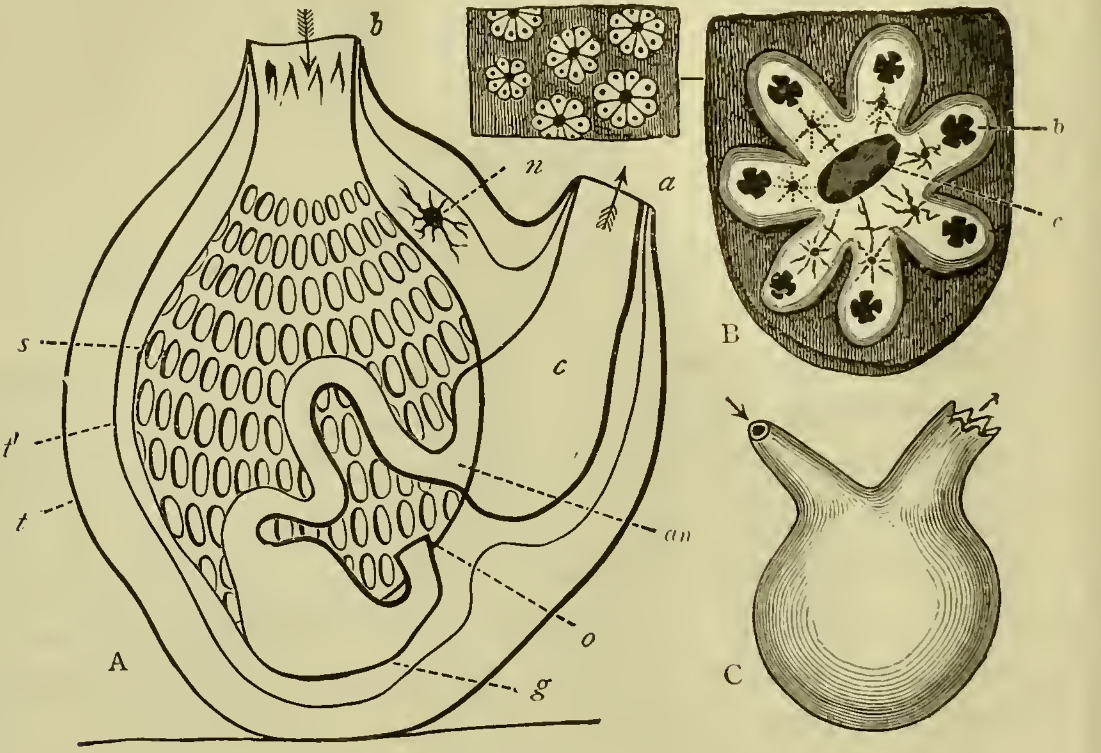

Fig. 177.—Structure of a Tunicate.

A, Diagram of the structure of a simple Tunicate: *t*, test; *t′*, second muscular tunic; *s*, branchial sac; *b*, branchial aperture; *a*, atrial opening; *c*, atrium; *o*, opening of gullet; *g*, stomach; *an*, anus; *n*, nerve-ganglion. B, *Botryllus smaragdus*—portion of a colony: *co*, common atrial pore; *br*, branchial aperture of one of the zoöids. C, a simple Ascidian (*Molgula*). (Nicholson.)

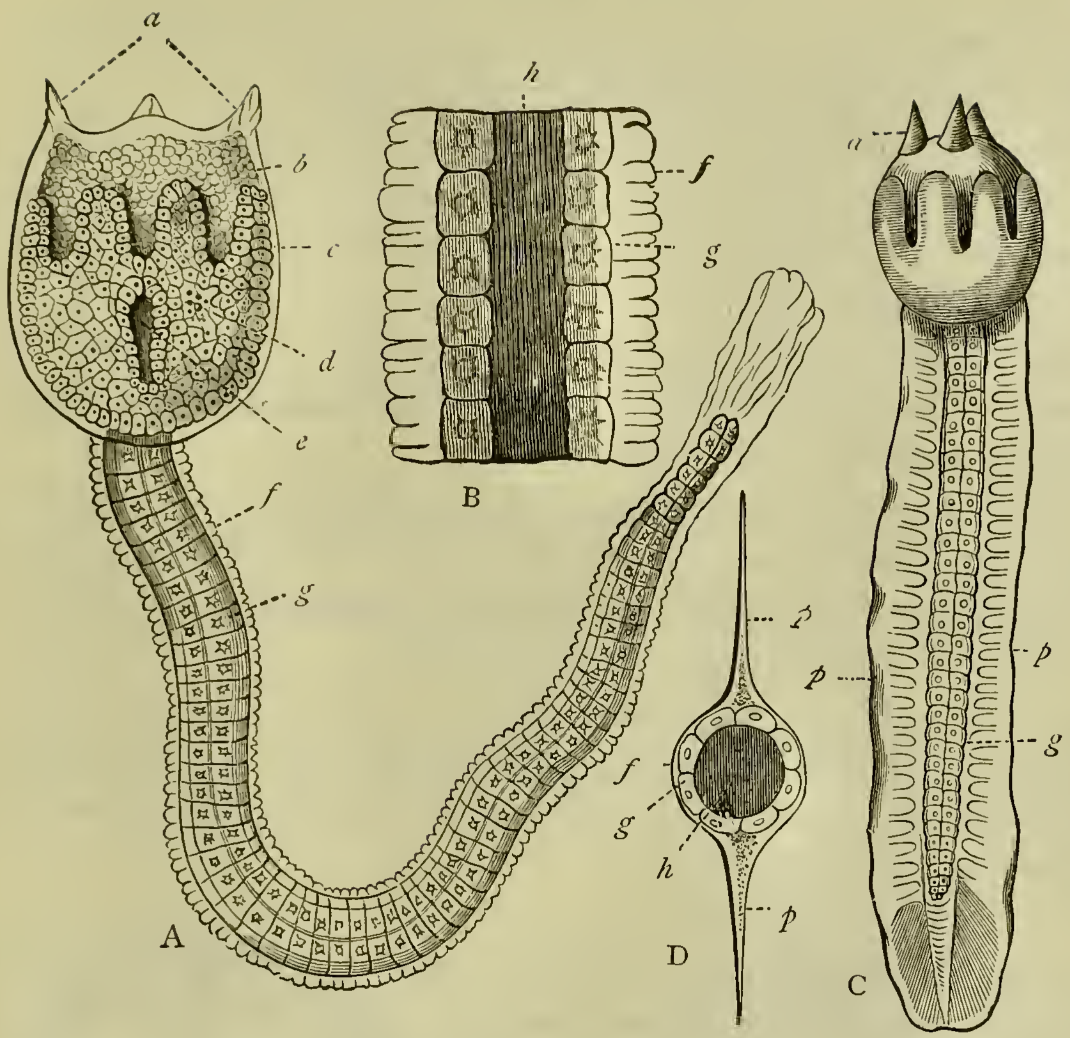

Fig. 178.—Development of a Tunicate.

A, Larva of *Botryllus*, greatly enlarged: *a*, processes for attachment; *b*, primitive cells from which digestive organs develop; *d*, eye-spot; *e*, entrance to branchial sac; *f*, external test; *g*, large cells forming central axis. B, Portion of tail, enlarged: *h*, central axis. C, Another larva. D, Diagrammatic cross-section of the tail: *p*, *p*, fins; *h*, central axis; *g*, cellular, and *f*, external sheath. (Nicholson.)

In *Amphioxus* (fig. 179) we have a permanent dorsal nervous system and notochord, this latter being an elastic cartilaginous

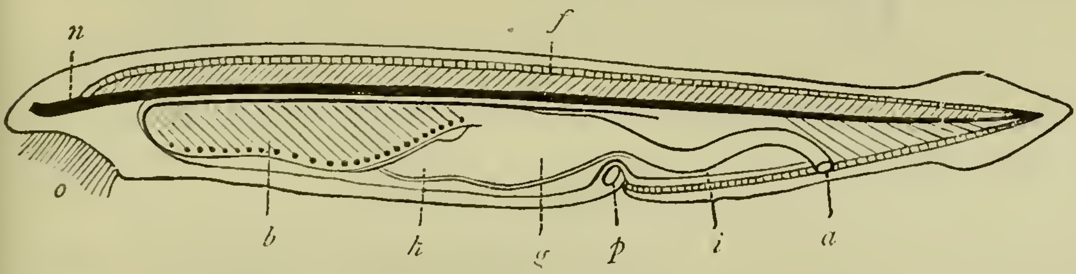

Fig. 179.—The Lancelet (*Amphioxus lanceolatus*).

o, Mouth; *b*, pharynx; *g*, stomach; *h*, liver; *i*, intestine; *a*, anus; *n*, notochord; *f*, fin-rays; *p*, abdominal pore. (Nicholson.)

rod between the nervous system and the gut. Couch places this little creature amongst the British Fish.

Another form to be mentioned here is the worm-like *Balanoglossus*, which Bateson has shown to have a dorsal axial rod (notochord) and a dorsal hollow nervous system, besides a series of gill-slits, like a fish.

The whole of those animals that possess a dorsal nervous system and a notochord during some period of their existence are best known, then, as **Chordata**.

The Chordata can again be divided into two sections—namely, the *Acrania* and the *Craniota*. The former contains those lowly intermediate forms which Mr Bateson classifies as follows :—

1. Hemichordata (Balanoglossus).
2. Urochordata (Ascidians).
3. Cephalochordata (Amphioxus).

Whilst Fish, Amphibia, Reptilia, Aves, and Mammalia may be placed in a fourth division—

4. Vertebrata.

Thus for the old term Vertebrata we now substitute Chordata, and use the term Vertebrata only for those Chordata with a cranium and a distinct skeleton, either cartilaginous or osseous, so that the Chordata tabulate as follows :—

Chordata	*Acrania* (no brain) .	1. Hemichordata.	
		2. Urochordata.	
		3. Cephalochordata.	
	Craniota (brain present)	4. Vertebrata	Pisces.
			Amphibia.
			Reptilia.
			Aves.
			Mammalia.

CHAPTER XI.

CHORDATA—*Continued.*

THE CHARACTERS OF CRANIOTA OR VERTEBRATE ANIMALS.

THE remaining divisions of the Chordata—namely, the Fish (Pisces), Frogs, &c. (Amphibia), Snakes, &c (Reptilia), Birds (Aves), and Quadrupeds (Mammalia)—are known as Craniota or true Vertebrate animals. Although these two great sub-kingdoms, the Invertebrata or Achordata and the Chordata or

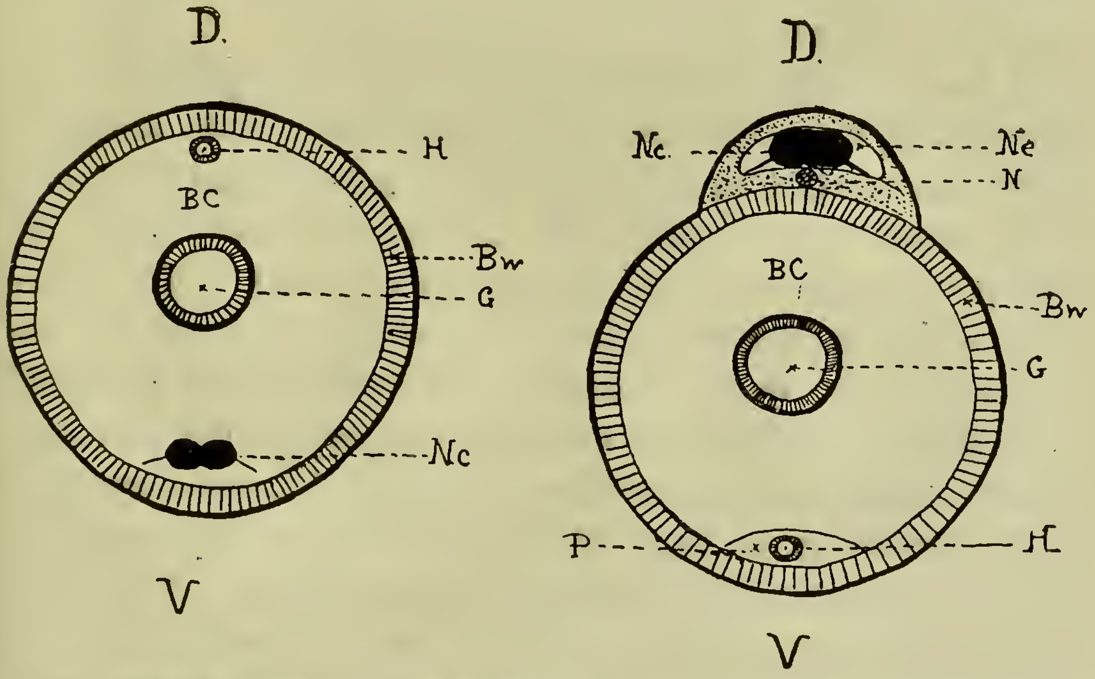

FIG. 180.—DIAGRAMMATIC SECTIONS OF AN INVERTEBRATE AND VERTEBRATE.

D, Dorsum; V, venter; *H*, hæmal or blood system; *Bc*, body cavity; *Bw*, body wall; *G*, gut; *Nc*, nerve chord; *Ne*, neural canal; *N*, notochord; *P*, pericardium.

Vertebrata, are united together by such forms as the Tunicates, yet each have their own distinctive characters.

On taking a transverse section of a vertebrate animal and comparing it with the same of an invertebrate (fig. 180), we shall note the following important differences. The section of the invertebrate consists of a single tube in which lie the dorsal hæmal system (*H*), the ventral nervous system (*Nc*), and the central gut (*G*). On comparing the vertebrate section, we observe that there are two distinct tubes, in one of which, the dorsal, is shut off the chief nervous system (*Ne*); in the other lie the gut and the ventral hæmal system—part of this latter, the heart, being further shut off by the membrane surrounding it, the pericardium (*P*).

Vertebrates (*Craniota*) may be said, generally speaking, to be characterised by having a dorsal nervous system which is enclosed in a canal composed of a number of bony or cartilaginous rings, the vertebræ, placed in a longitudinal row. In all vertebrates the structure called the *notochord* (*N*) is present in the embryo, and more or less so in the adult. This structure, which is developed in the floor of the neural canal, is a gelatinous, cartilaginous, axial rod, tapering at each end, and forming a support to the cerebro-spinal canal. The notochord, which is persistent in *Amphioxus*, is replaced in true vertebrata by the vertebral column. This column is composed of a series of cartilaginous or ossified segments, the vertebræ, between which the primitive notochord becomes squeezed out, it remaining as only small pads between the vertebræ, or as diamond-shaped masses, as we see in Fish. The limbs of vertebrates are never more than four in number, and are always turned away from the neural or dorsal surface; they are united to the body by distinct articulations. They are often absent in the lower vertebrates (Snakes); in Fish they are represented by the paired pectoral and pelvic fins (fig. 198, *p* and *v*).

Although a vascular system occurs in the Invertebrates, it is of a very primitive type compared to the blood-system of the Vertebrata. In all Craniota there is a contractile heart, which never consists of less than two distinct chambers (fig. 199), with valvular openings; more generally the heart is composed of four distinct divisions (fig. 195). In the lowest vertebrates this heart only pumps the blood to the respiratory organs to be purified, but in the higher forms there are two distinct vascular systems—one by which the blood is pumped to the lungs and then back to the heart, called the "pulmonary circulation"; the other by which the blood that has been to the respiratory organs is sent to the various parts of the body, the so-called "systemic circulation." Again, in this sub-kingdom there is always present a modification of the venous system known as the *hepato-portal* system, by which some of the blood sent to the intestinal portion of the alimentary canal is taken by a tube called the *vena porta* back to the liver, and not direct to the heart.

In connection with the venous system is also found in all Craniota a set of vessels along the walls of the gut, which take up the products of the intestinal digestion and pour them into the great vein, or vena cava. This system of vessels is known as the *lacteal system.* The substance contained in this system is *chyle*, and the main duct opening into the vena cava is designated the *thoracic duct* (fig. 195, *Td*). There are also certain embryonic characters common to the vertebrates. In all embryos we find two structures present—namely, the "primitive groove" and the "visceral arches." The primitive groove makes its appearance in the ovum early in development; it is found as a long depression in the germinal area of the egg, with raised lip-like sides; and at the bottom of this canal the notochord is seen. These early stages of development will be treated more fully in the Embryology of the Fowl, where we shall observe that at no time does the nervous system surround the gut anteriorly as in the lower animals, and that it commences as an open tube.

The next most important embryonic structures are the so-called "visceral arches." These are a series of transverse ridges developed at the sides of the embryo just posterior to the head. Slit-like openings become formed in them, the "visceral clefts," by which a free communication is set up between the external media and the inner part of the digestive tube anteriorly. These clefts are found in all Craniota ; but they are only persistent in Fish and some Amphibia, in which filaments are formed on the inner parts of the clefts, the branchiæ or gills. Although not seen in the higher adult forms, they are nevertheless always present in the embryo.

In connection with the development there are also to be noticed two embryonic membranes—namely, the *Amnion* and *Allantois* (fig. 235).

Before we can study the groups of the Craniota, it is certainly necessary that we should know something of the typical vertebrate structure. For studying the structure we will take the Horse as our type, as by so doing we shall be able to compare more easily the peculiarities of the various farm animals.

CHAPTER XII.

THE STRUCTURE OF THE HORSE.

In the structure of a craniote animal there are two main divisions to be studied—namely, the skeletal structure and the general internal organisation. Every craniote animal has an internal skeleton. In the lowest forms, the fish, this skeleton may be soft and composed only of gristle-like cartilage; or it may be completely ossified or bony, as in the horse. Bony or osseous tissue is partly preceded by cartilaginous tissue: the bones of young animals are quite soft as compared with the bones of the adults, because the calcareous salts which form the bone are not yet fully deposited. Bones are also formed by calcareous deposits in membranes.

Skeleton of the Horse.

The skeleton of the horse (fig. 181) will be seen, in common with that of all the Craniota, to be easily divisible into two parts—the axial part or spinal column and the cranium, and the so-called appendicular portion, composed of the limbs and their arches. The limb-arches unite the limbs to the central or axial skeleton, and with these arches the limbs articulate.

The trunk or vertebral column is composed of a number of bony rings—the vertebræ. These bony vertebræ are placed in a longitudinal direction. There are five divisions of these bones, which are known as *cervical*, *dorsal*, *lumbar*, *sacral*, and *coccygeal* vertebræ. The cervical are found

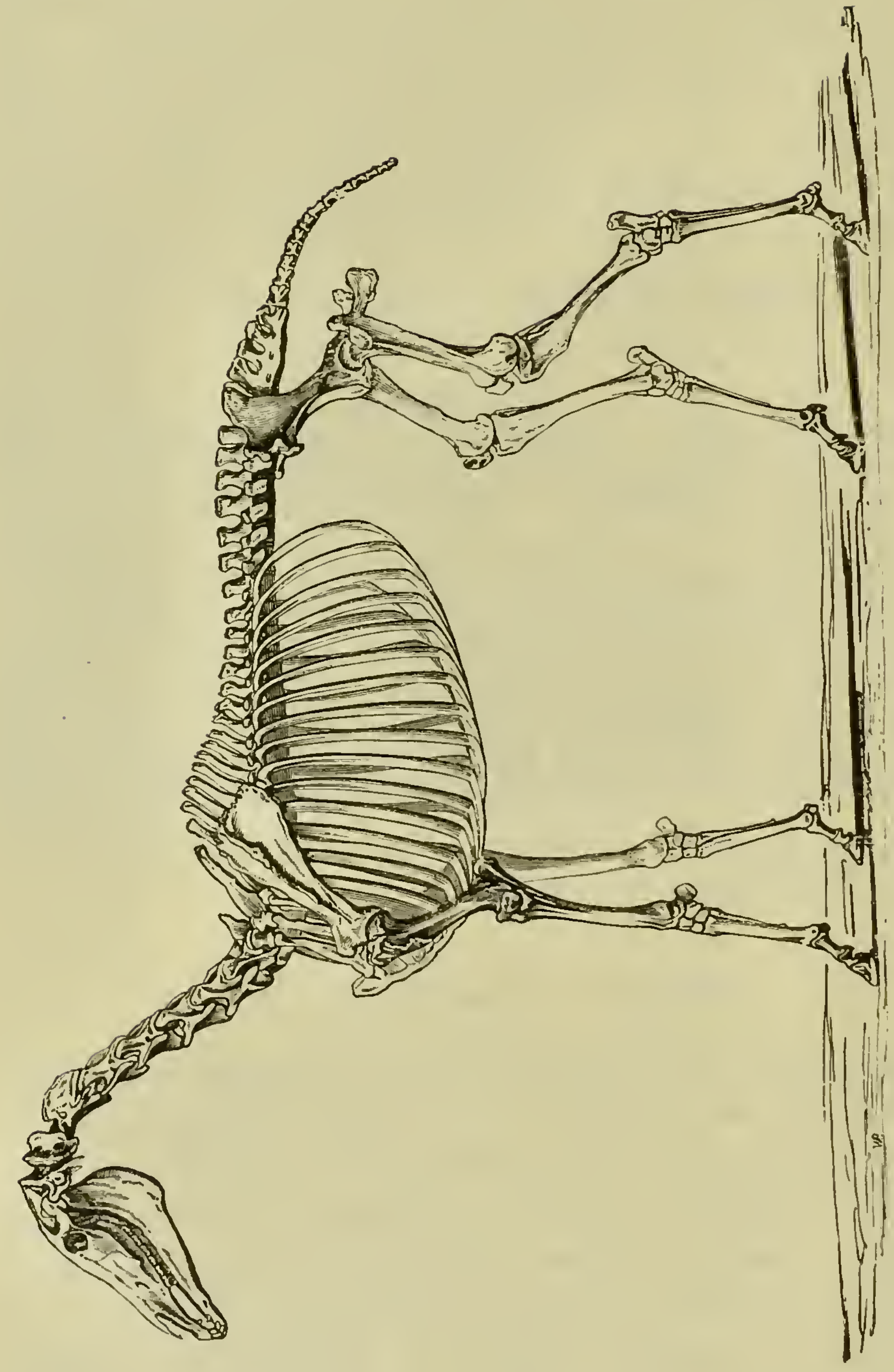

Fig. 181.—Skeleton of Horse. (Chauveau.)

Note 18 pairs of thin ribs, and single toe.

in the neck ; the dorsal carry the ribs ; the lumbar are found in the region of the loins ; the sacral are united into one bony mass called the "sacrum," which supports to some extent the hind limbs and the pelvic arch ; the coccygeal form the tail-region. A typical vertebra (fig. 182) consists of a solid lower portion, the *centrum* (1 and 2), and an upper bony arch, the *neural arch* (4), in which lies the spinal cord. At the point where the two halves of the neural arch meet there springs a bony spine more or less developed, the *dorsal* or *neural spine* (fig. 182, 3). On each side of the neural arch a process juts out, the *zygapophysis* (5 and 7). From the sides of the vertebræ there also project a lateral process on each side, called the *transverse process* (6).

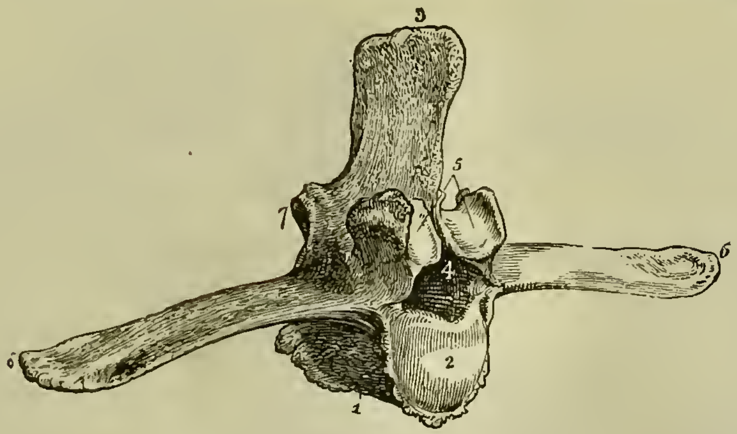

FIG. 182.—LUMBAR VERTEBRA (Front view.)

1, Centrum ; 2, its facet ; 3, dorsal spine ; 4, spinal foramen ; 5, anterior articulating process ; 6, transverse process ; 7, posterior articulating process (Chauveau.)

Theoretically there is another arch below the centrum, the so-called hæmal arch, which protects the blood-system. But this can only be recognised in some animals, unless we take the ribs as partly forming the arch. It is best seen in the caudal vertebra of some fish. The vertebræ unite together partly by their centra and partly by the zygapophyses. When a vertebra has both faces of the centrum scooped out it is called an *amphicœlous* vertebra ; when one end (the anterior) is projecting and the posterior concave, it is termed *opisthocœlous ;* when concave in front and convex behind, *procœlous.*

In the horse the cervical vertebræ are seven in number.

This is the general number in all mammals; even the long neck of the giraffe has only the same number as the short neck of the pig.[1] The cervical vertebræ are cubical in form, the first two being modified. The first is known as the *atlas* (fig. 184), which is simply a bony ring with which the skull articulates in front; there is no centrum to this vertebra. The second vertebra is called the *axis* (fig. 183): this is more like a typical cervical; but in front it has a projecting blunt process coming from the centrum, the so-called *odontoid process* (2), by which the axis can always be identified. The thoracic vertebræ number eighteen, to which articulate the ribs. The thoracic vertebræ have large flat and broad neural spines, the spines being longest in the anterior vertebræ in the region of the horse's "withers," and directed backwards. The lumbar vertebræ are six in number; they are small and stout, with very broad wing-like lateral processes. The sacral vertebræ, of which there are five in the horse (except in Arabs, which have six), are united in the adult into one bony piece, the sacrum, which supports the pelvic arch.

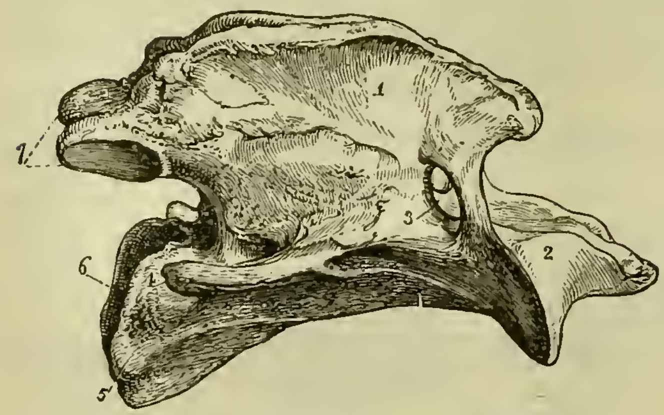

FIG. 183.—AXIS. (Lateral view.)

1, Superior spinous process; 2, odontoid process; 3, intervertebral foramen; 4, body; 5, inferior spinous process; 6, 7, inferior and superior articulating processes. (Chauveau.)

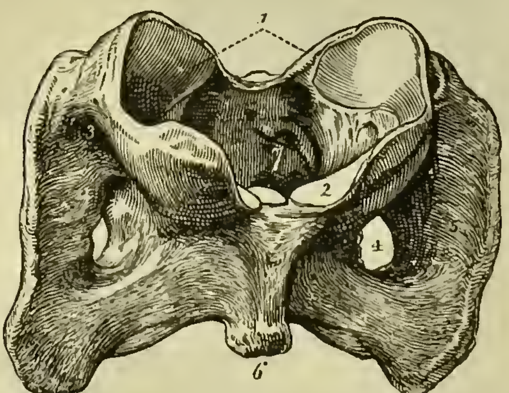

FIG. 184.—ATLAS. (Inferior surface.)

1, Articular cavities for condyles of occipital bone; 2, articular facet; 3, vertebral foramen; 4, cervical foramen; 5, transverse process; 6, inferior spinous process; 7, superior arch. (Chauveau.)

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[1] Some Edentate mammals, such as the Three-toed Sloths, have a varying number of cervicals, some genera six, whilst others have nine.

The caudal vertebræ number sixteen to eighteen; they are reduced to little bony cylinders. No closed neural canal runs down them after the third or fourth vertebra.

The *skull* or *cranium* (fig. 185), which articulates with the axis by two bony projections, the two occipital condyles (*OC*), is divided into two regions, the cranial and facial. The former is a bony box which contains the *brain*. The facial part constitutes the largest area of the skull. The skull, which is an elongated pyramidal box in the horse, is built up of a great number of bones (fig. 185). Only a few of the more important can be mentioned here; for further details the reader must consult various works on osteology and veterinary anatomy.

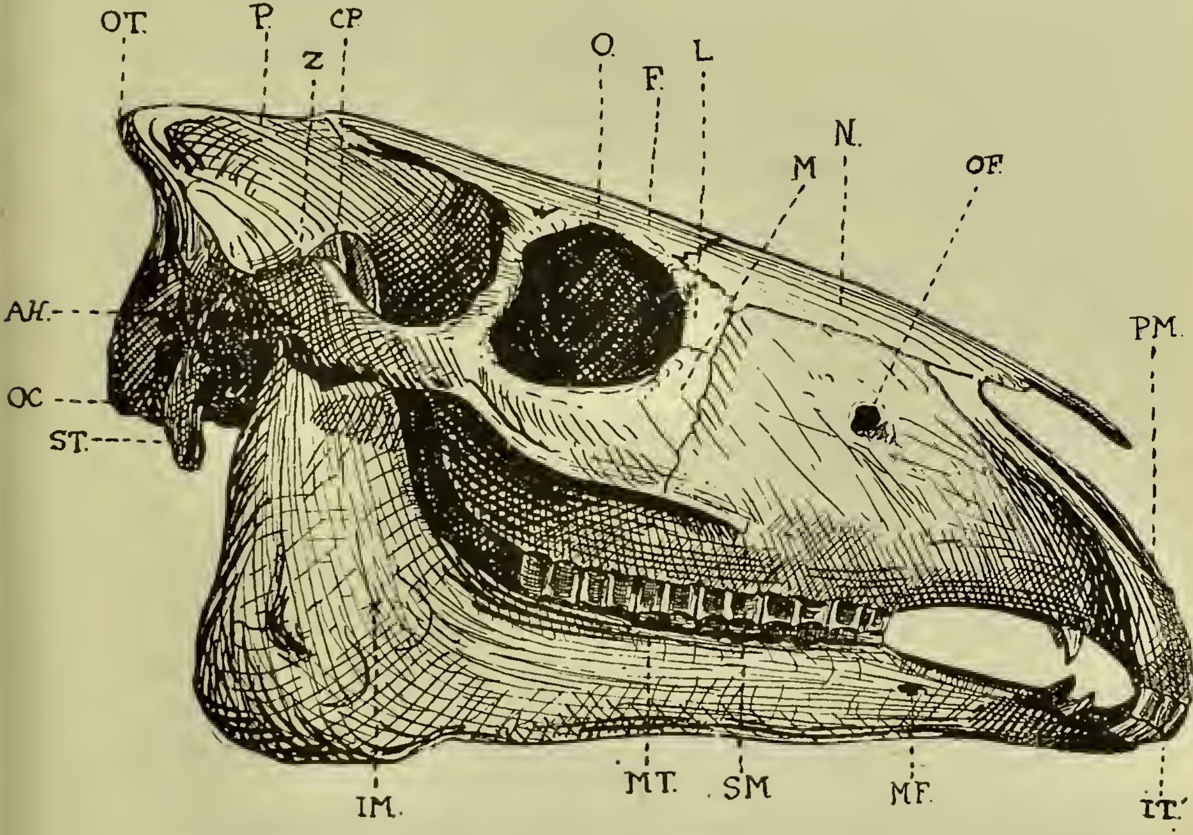

FIG. 185.—SKULL OF THE HORSE.

OC, Occipital condyle; *ST*, styloid process; *OT*, occipital tuberosity; *P*, parietal bone; *AH*, auditory region; *Z*, zygomatic process of temporal bone; *F*, frontal bone; *O*, orbit; *L*, lachrymal bone; *M*, malar; *N*, nasal bone; *SM*, supra-maxillary; *OF*, infraorbital foramen; *PM*, premaxillary; *IT*, incisor teeth; *MT*, molar teeth; *IM* inferior maxillary; *CP*, coronoid process.

The cranium is surrounded by flat bones at the back: these bones are known as occipital bones (fig. 186, *So*, *Ex.O*, *Bo*), of which there are several; these are perforated by a large round hole, the foramen magnum, out of which passes the portion of the brain, the medulla oblongata, connecting the former with the spinal column. Beneath this opening are the two swellings, the occipital condyles. The top of the cranium is composed of four flat thin bones: the ones joining the occipitals are the *parietal* bones (*P* (fig. 185) and *Pa* (fig. 186)), and those in front of the parietals are the *frontals* (*F* and *Fr*); these extend behind the eye-regions. The sides of the skull are partly shut in by the *temporal bones* with the zygomatic processes (*Z* and *Sq*).

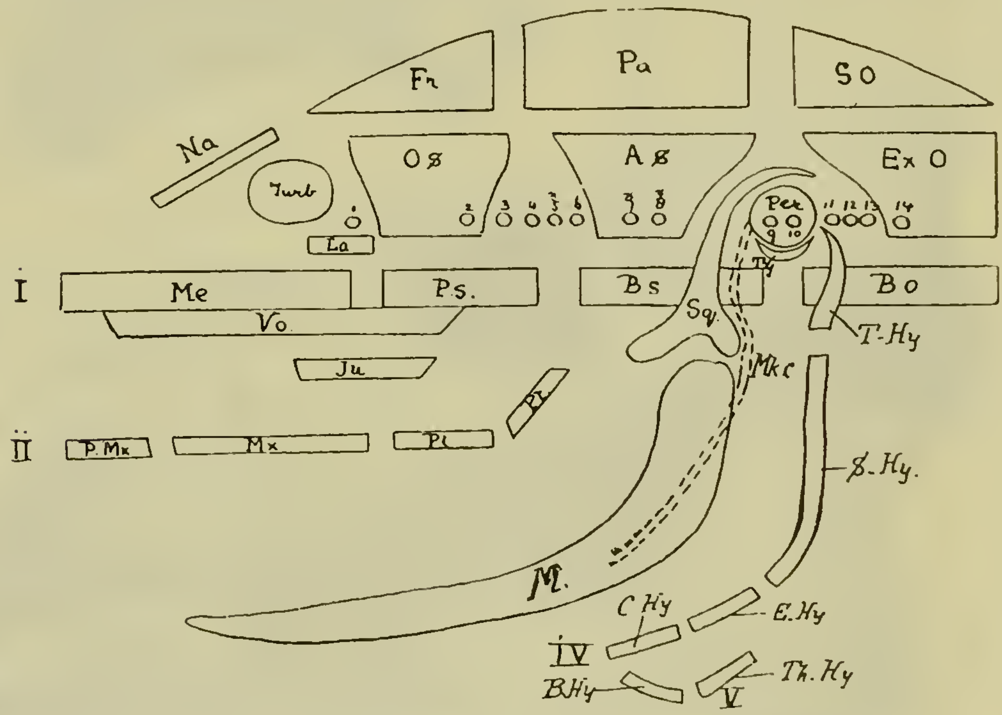

Fig. 186.—Diagram of the Relations of the Principal Bones of the Mammalian Skull.

Me, Mesethmoid; *Ps*, presphenoid; *Bo*, basioccipital; *Bs*, basisphenoid; *Os*, orbitosphenoid; *Fr*, frontal; *Ex.O*, exoccipital; *SO*, supraoccipital; *Na*, nasal; *Turb*, turbinals; *Per*, periotic; 1, position of exit of olfactory nerve; 2, optic nerve; 3, motor oculi nerve; 4, trochlear nerve; 5, 7, 8, three divisions of 5th nerve; 6, abducens oculi; 9, facial; 10, auditory; 11, glosso-pharyngeal; 12, pneumogastric; 13, spinal accessory; 14, hypoglossal; *Sq*, squamosal; *Ty*, tympanic; *Vo*, vomer; *P.Mx*, premaxilla; *Mx*, maxilla; *Pl*, palatine; *Pt*, pterygoid; *Ju*, malar; *La*, lachrymal; *M*, mandible; *Mk.C*, Meckel's cartilage; iv, anterior hyoid arch; v, posterior hyoid arch. (After Flower.)

The sphenoid bones (*As*, *Os*, *Ps*, and *Bs*) shut in the side of the cranium partly, and lie between the occipitals, frontals, palatine (*Pl*), vomer (*Vo*), pterygoid (*Pt*), ethmoid, and temporals.

The central part of the facial area is formed by two *nasal bones* (*N* and *Na*), flat bones of an elongated triangular form extending down the nasal cavities. Placed on each side of these central ones are the supra-maxillary bones (*SM*), which carry teeth. In front come the two other tooth-bearing bones, the *premaxillaries* (*P.Mx* and *PM*). In the nasal tubes are two spongy structures, the *turbinated bones* (*Turb*); and between the facial and cranial portion comes the *ethmoid*, which is perforated in one part, forming the *cribriform plate*, situated at the end of the nasal fossæ. The floor of the facial area (or the roof of the mouth) is built up of *vomers* (*Vo*), premaxillaries, maxillary, and *palatine* (*Pl*) bones.

The lower jaw is composed of two *rami*, united in the middle line in front by a symphysis, each half bearing teeth (*IM*). The lower jaw articulates with the skull at its posterior end.

The *ribs*, of which there are eighteen, rarely nineteen, pairs, form a kind of box in which are lodged some of the organs of the body, which they protect, especially the respiratory organs and heart. Each rib articulates with two vertebræ. The end of the rib nearest the vertebræ has two heads—one the *capitulum*, the other the *tuberculum*. The front ribs are flattest, and as they pass back they become more and more arched. A rib consists of two portions—the true bony rib, which unites with the vertebræ, and a cartilaginous portion, the costal cartilage, which unites the rib with the sternum or breast-bone. The first eight pairs of ribs unite with the sternum separately by their costal cartilages. The other ten pairs have their costal cartilages united, and meet all together with the "breast-bone." The former are the *true ribs*, the latter the *false ribs*. The breast-bone or *sternum*, with which the ribs unite, is a narrow keel-shaped bone, partly composed of cartilage.

The *anterior arch* and *limb* are closely united by a distinct articulation forming a ball-and-socket joint. Nevertheless the fore-limb of the horse is not able to completely rotate, as is the case with the human arm. The *anterior* or *pectoral arch* is typically composed of six bones—two *scapulæ*, two *coracoids*, and two *clavicles*. In the horse this so-called shoulder girdle is very simple; the coracoids are reduced to mere fragments, small processes attached to the shoulder-blades or scapulæ, and known as the coracoid processes. No *clavicles* or collar-bones are found at all. The arch is really reduced to a pair of large scapulæ. The scapula is shallow, broadened above and contracted below, where we find a depression, the *glenoid cavity*, in which fits the head of the arm-bone or humerus. At the top of each scapula is a cartilaginous prolongation rounded at its summit, and down the outer face of the scapula runs a bony ridge: this ridge is much thickened and turned backwards above the middle. By noticing this point, we can easily tell a right from a left scapula.

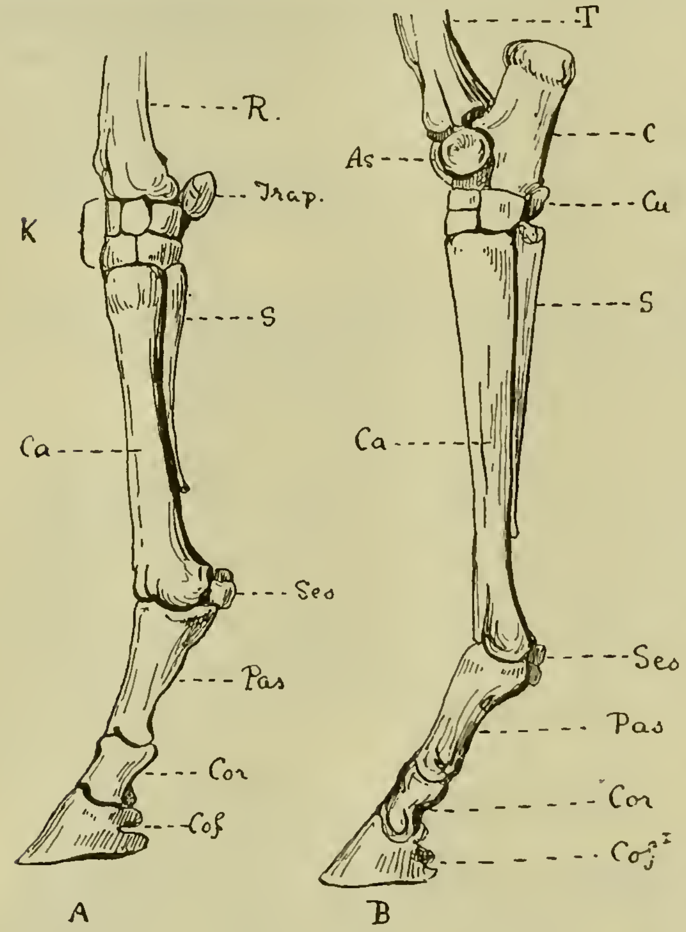

Fig. 187.—A, Fore, and B, Hind Leg of Horse.

R, Radius; *K*, knee (carpus); *Ca*, cannon-bone; *S*, splint-bones; *Pas*, pastern; *Cor*, coronet; *Cof*, coffin-bone; *Trap*, pisciform; *Ses*, sesamoid bone; *T*, tibia; *As*, astragalus; *C*, calcaneus; *Cu*, cuboid.

The *fore-limb* (fig. 187, A) of the horse consists of the following parts: the *humerus*, the *radius* (*R*) and *ulna*, the *carpus* (*K*) (or knee of the horse), the *metacarpus* or cannon-bone (*Ca*), and the *phalange-bones*, consisting of three divisions. Normally in animals there are five metacarpals and five phalanges or digits, such as we see in man; but in the horse these latter are reduced to one. The fore-limb, which is only capable of a backward and forward movement, is articulated by the head of the humerus with the pectoral arch at the glenoid cavity. The humerus of the horse can be easily felt, although it is hidden beneath the muscles and skin in the "shoulder." This humerus is a short stout bone with two large swellings, the *trochanters;* the *head* is smooth and convex, and the distal end marked by two grooves. The head and glenoid cavity form a ball-and-socket joint; the distal end and the radius and ulna articulation form a hinge-joint, capable only of a swinging motion.

The forearm consists of two bones, the *radius* and *ulna.* In man these two bones are quite distinct, but in the horse they are united (*R*). The radius forms the chief bone articulating with the distal end of the humerus and at its own distal end with the knee-bones (*K*). The ulna is fused with the radius, and terminates in a slightly swollen extremity about half-way down the radius; at its proximal end it rises above the radius over the end of the back of the humerus, forming the *olecranon process.*

The radius articulates with the carpus or "knee" of the horse. The *knee* (*K*) is composed of seven cubical bones, with flat articulating surfaces arranged in two rows, forming three distinct joints, one between the radius and first row, another between the two rows of carpal bones, and a third between the carpus and metacarpals. The bones of the two rows are the *unciform*, *magnum*, and *trapezoid*, forming the lower row; the *cuneiform*, *lunar*, and *scaphoid*, forming the upper row; and a separate bone, the *pisciform* (*Trap*), behind. Sometimes there is a fourth bone in the lower row, the *trapezium.*[1] Each bone has a delicate serous membrane surrounding it, the *synovial membrane*, which secretes a lubricating fluid of a yellowish greasy nature called synovium. This lubricating agent is not an oil but an albuminous substance.

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[1] The trapezium is a pea-like bone at the back of the knee, a vestigial remains which I have never been able to find.—(G. T. B.)

The unciform, magnum, and trapezoid articulate with the metacarpal bones. Normally these are five in number, as seen in man; but in the horse only one entire digit remains, *the third*; portions of the second and fourth are found as the so-called "*splint-bones*" (fig. 187, *S*). The metacarpal bone of the horse is the *cannon-bone* (*Ca*), and the two rudimentary ones the splint-bones, one on each side of the cannon-bone, uniting with it about halfway down. The remaining bones of the fore-limb constitute the horse's foot. The foot is composed of three bones: the one uniting with the cannon-bone is called the *pastern* (*Pas*), which is the largest; this is followed by the *coronet-bone* (*Cor*); the last, or *coffin-bone* (*Cof*), being hidden in the hoof. These form the true digit, the equivalent of our third finger. There are also present two detached bones, or sesamoid bones. One of these sesamoid bones is present at the back of the joint formed by the cannon and pastern (*Ses*); the other, the *navicular bone*, is found behind the junction of the coronet and coffin bones inside the hoof. Various bony deposits occur abnormally in this region, such as "side-bone" and "ring-bone." "Side-bone" is a calcareous deposit on the sides of the coffin-bone. "Ring-bone" is a similar deposit on the coronet.

The *posterior arch* and *limb* are homologous to the anterior. The posterior arch (fig. 188) is called the pelvic arch or hip-girdle, and is made up of two large bony masses united in their middle line, the *ossa innominata*. Each os innominatum is formed by three bones known as the *ilium* (1), *ischium* (12), and *pubes* (9), the six forming a kind of bony ring, the pelvis, which is much larger in the female than the male. The *ilium* is a triangular bone projecting forwards, and forms the so-called haunch-bone. There are two noticeable parts in it, the anterior spine and the posterior spine, the latter pointing upwards, the former forwards. The *ischium* passes backwards towards the tail. The pubes are the two flat bones which unite beneath at a point of union called the pubic symphysis. The pubes are perforated by the two large *obturator foramina* (10). The three bones of each os innominatum unite at one point towards the posterior part of the pelvis, forming a concavity called the *acetabulum* (5). The ischium on each side lies against the sacrum, to which they are attached by muscle. Into the acetabulum or cotyloid cavity fits the head of the thigh-bone or femur, forming a ball-and-socket joint similar to the one at the junction of the fore-limb and arch. The *femur* is a thick solid bone with a large smooth head, at the side of which is developed a large roughened projection called the *trochanter major*. About one-third of the way down the bone is a swelling or tuberosity found only, fully developed, in Solipeds (Horses, &c.)—namely, the third trochanter—to which are attached vari-

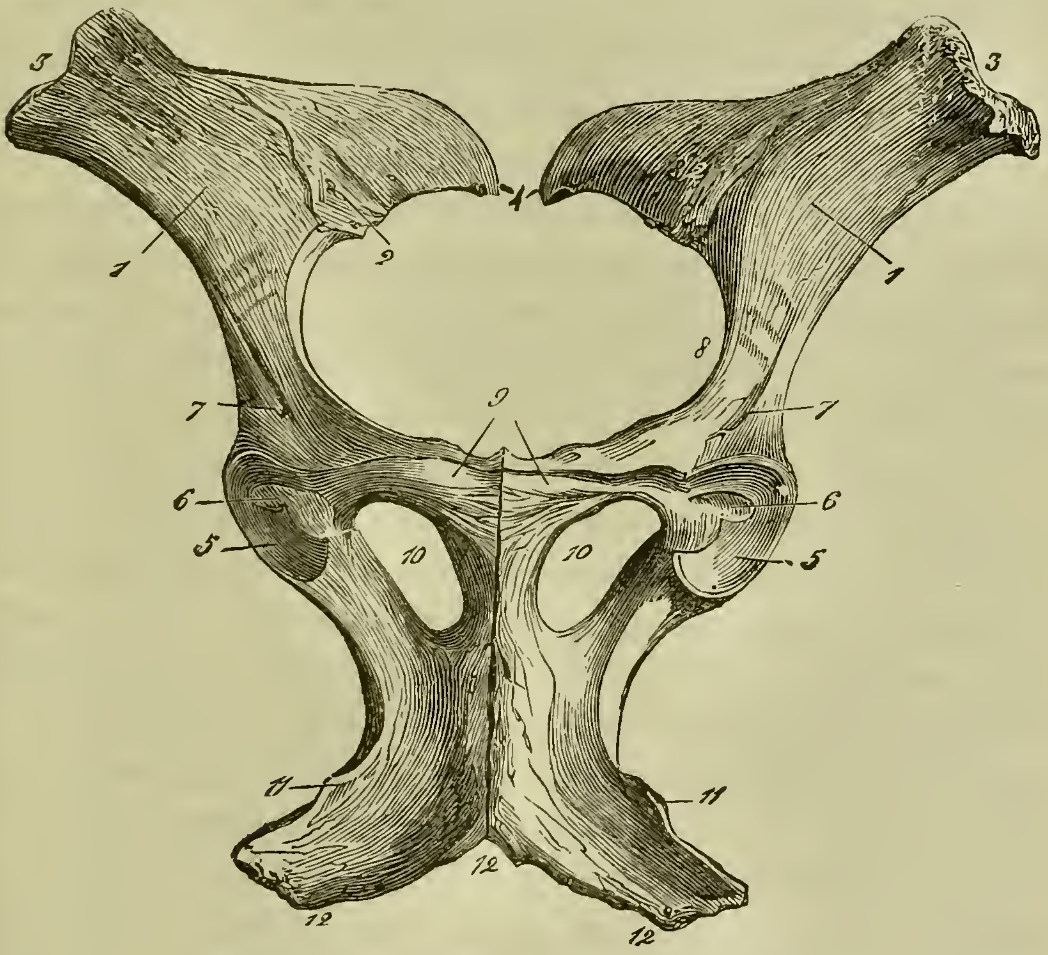

FIG. 188.—PELVIC ARCH. (Seen from below.)

1, Iliac surface; 2, auricular facet; 3, crest of ilium; 4, angle of haunch; 5, cotyloid cavity; 6, bottom of ditto; 7, one of the imprints for the insertion of the rectus femoralis; 8, ileo-pectineal line; 9, channel on the external face of pubes; 10, obturator foramen; 11, sciatic spine; 12, ischiatic arch. (Chauveau.)

ous powerful muscles for the movement of the limb. The chief motor muscle of the hind-leg is united to the trochanter major. Following and uniting with the femur are the two bones, the *tibia* (fig. 187, B, *T*) and *fibula*, which are quite detached in certain animals. In the horse the tibia is well developed, being a stout strong bone, whilst the fibula is much reduced in size and anchyloses with the tibia. The joint formed by the junction of these two bones with the femur is known as the *stifle-joint*. In front of this joint is a floating bone, the *patella* or knee-cap, which is attached by three bands of ligament to the tibia.

The tarsus or ankle forms the horse's *hock*; like the carpus or knee, this is made up of several small bones. There are six tarsal bones in all, known as the *external* and *internal cuneiforms*, *cuboid* (*Cu*), *navicular*,[1] *astragalus* (*As*), and *calcaneus* (*C*).

The astragalus is in front of the hock, at the top uniting with the tibia. The calcaneus is behind the astragalus, and projects upwards behind the tibia, forming the point of the hock; it also has an articulating surface with the tibia. Below the calcaneus is the cuboid. Beneath the astragalus comes the navicular, scaphoid, or large cuneiform; the lower row consisting of the internal and external cuneiforms, the latter being chiefly at the back of the hock. The metatarsal or cannon-bone (*Ca*) is very similar to that of the fore-limb. The foot is also similar in structure, but the ultimate toe-bone is called the *pedal* bone (fig. 187, B, *Cof* $^{\text{i}}$); and at the junction of the cannon-bone with the large pastern are two floating bones behind (B, *Ses*), which are covered by a horny growth, the *ergot*, upon which is attached the tuft of hair called the *fetlock*.

This completes the skeleton, whose function is for the attachment of the muscles and for the protection of the various soft inner parts of the body.

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[1] The navicular is also called the scaphoid or centrale. The latter term is best, as there is a scaphoid in the carpus, and the true navicular is a detached sesamoid bone in the foot, the seat of the navicular disease.

INTERNAL ANATOMY.

The skin, or outer covering of the muscles, skeleton, and organs, also represents the organ of "touch"—certain areas, such as the lips and limbs, being especially adapted to this sense. The skin is composed of two layers—the outer the *epidermis,* the inner the *dermis.* The epidermis is the thin layer covering the face of the derma, and is formed of flat cells, which are continually being deposited and worn off by friction. The derma forms the chief thickness of the membrane, its inner face adhering closely to the subjacent parts by the *panniculus adiposus,* a cellulo-adipose substance. The external face is perforated by openings for the hairs and exits of the sudoriporous and sebaceous glands. The nerves end in the upper part of this layer in little papilla-like projections.

The skin of the horse having been removed, there is found underneath a thick coating—thin, however, in places—of a red, more or less striped appearance, which can easily be divided up into different detached areas. These are the muscles, the so-called flesh which is attached to the bones, forming not only a covering for the more delicate internal parts, but also a very complicated mechanical apparatus for the movement of the animal, &c. The individual groups of muscles on examination will be seen to be composed of a number of bundles of fibres, each of which is endowed with the power of contraction. During this contraction a muscle becomes shorter and stouter: on the contraction ceasing the muscle regains its normal length by an elastic recoil, muscle being also elastic in nature. Many muscles terminate in *tendons;* these latter, and the muscles themselves, are attached at each end to a bone. For such a purpose are the roughened ends of the femur and the side swelling of the third trochanter formed. When the muscle contracts, one end to which the muscle or tendon is attached must give way and be pulled towards the other, and thus the move-

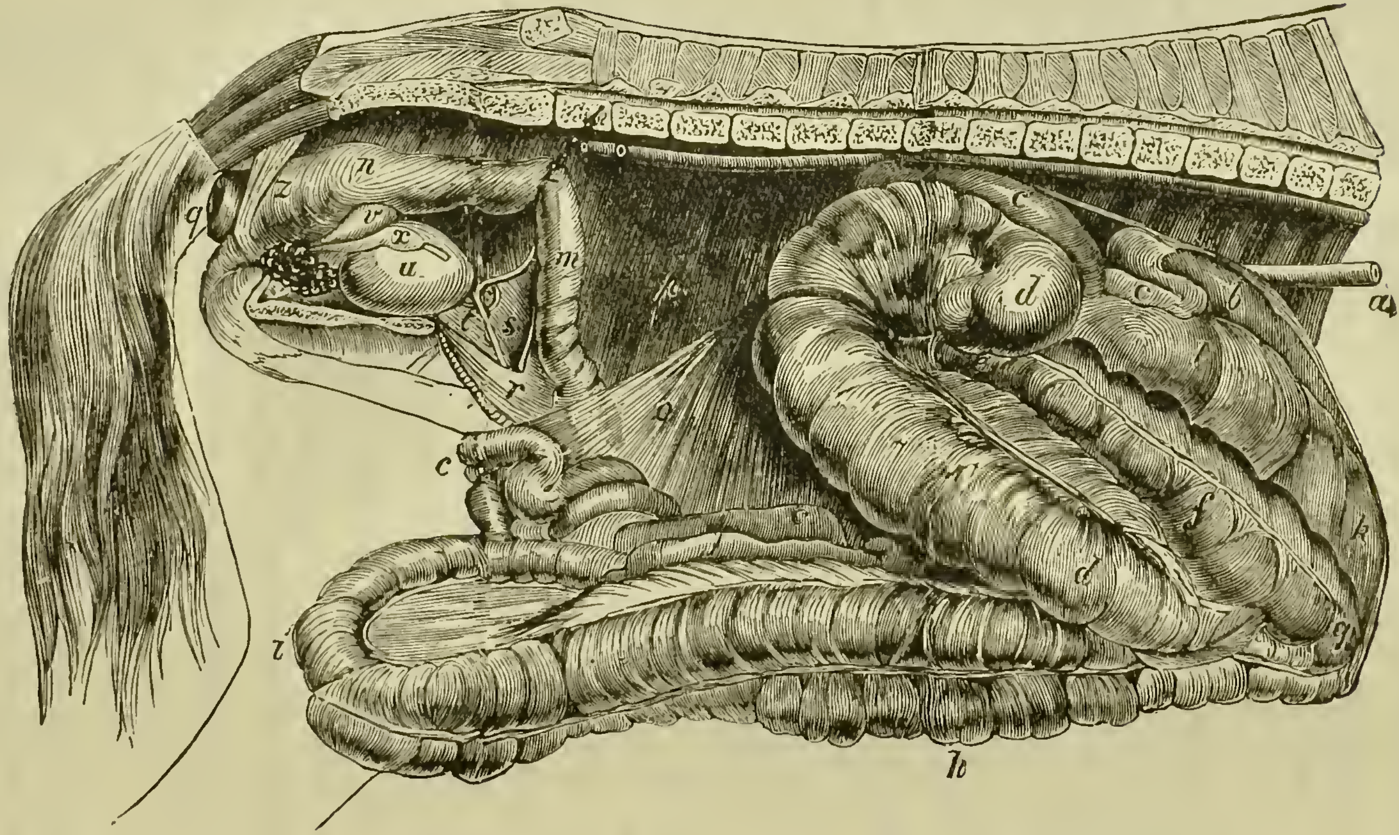

FIG. 189.—GENERAL VIEW OF THE INTESTINES OF THE HORSE. (Seen from right side.) (Chauveau.)

a, Œsophagus; *b*, right sac of stomach; *c*, small intestine, with duodenum encircling cæcum; *d*, cæcum; *e*, origin of large colon; *f*, first part of large colon; *g*, supra-sternal flexure; *h*, second part of large colon; *i*, pelvic flexure; *j*, third part of large colon; *k*, diaphragmatic flexure; *l*, fourth part of large colon; *m*, termination of free colon; *n*, rectum; *o*, mesentery proper; *p*, meso-colon; *q*, anus; *r*, internal inguinal ring; *s*, spermatic vessels; *t*, deferent canal; *u*, bladder; *v*, vesiculæ seminales; *x*, pelvic enlargement of vas deferens; *y*, prostate; *z*, suspensory ligament of penis.

ments of the body are brought about. Into the grouping of these muscles we have not space to enter here.

In a transverse section of the horse two cavities will be seen—the dorsal tube with the spine, and the large ventral abdominal cavity. In a longitudinal section three cavities will be exposed—the long neural tube, and the body divided also into two by a membranous partition, the *diaphragm* (fig. 190, *Di*), the front division being the *thorax*, the posterior the *abdomen.*

The *digestive tube* or alimentary canal (figs. 189 and 190) may be said to commence at the back of the mouth in a large space, the pharynx (*P*), which is situated behind that part of the roof of the mouth known as the soft palate (*Sp*). From the pharynx a small opening leads into the gullet or œsophagus (*OE* and *a*), which passes through the neck in close relation to the windpipe or trachea (*T*), and enters the thorax in its upper moiety, runs through it, and perforates the diaphragm dorsally. The stomach (*St* and *b*) receives the œsophagus at its inner margin or greater curvature towards one end. The stomach of the horse is a simple sac elongated transversely, and lies across the ab-

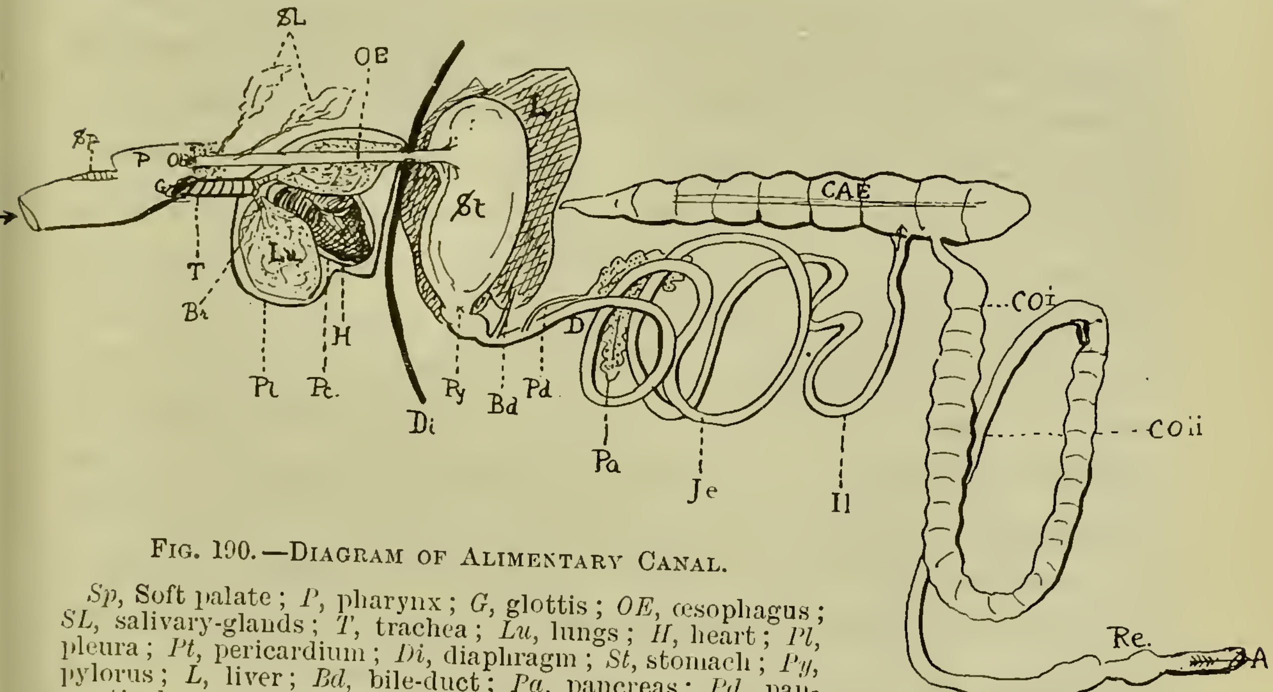

FIG. 190.—DIAGRAM OF ALIMENTARY CANAL.

Sp, Soft palate ; *P*, pharynx ; *G*, glottis ; *OE*, œsophagus ; *SL*, salivary-glands ; *T*, trachea ; *Lu*, lungs ; *H*, heart ; *Pl*, pleura ; *Pt*, pericardium ; *Di*, diaphragm ; *St*, stomach ; *Py*, pylorus ; *L*, liver ; *Bd*, bile-duct ; *Pa*, pancreas ; *Pd*, pancreatic duct ; *Re*, rectum ; *A*, anus ; *D*, duodenum ; *Je*, jejunum ; *Il*, ileum ; *CAE*, cæcum ; *Co*^{i} and *Co*^{ii}, colon.

dominal cavity. The œsophagus enters towards that end of the gastric cavity known as the cardium, the other end being called the pylorus. On opening the stomach we can distinguish a right and a left half. The right half or pyloric half is lined by a red mucous membrane, the left by a white mucous membrane, which is partly continuous with the lining epithelium of the œsophagus, which it receives. The right half only has, in its mucous membrane, true digestive glands or gastric glands ; the left is in reality part of the œsophagus much dilated. From the pyloric end (*Py*), at which we may notice a constriction, arises the commencement of the small intestine. The small intestine is divided into three parts—the *duodenum* (*D*), which leaves the pylorus, the *jejunum* (*Je*), and the *ileum* (*Il*). The small intestine is a long thin-walled tube much folded and convoluted, and lies especially on the horse's left flank. It is 24 yards long in the horse and about 1¾ inch in diameter. The jejunum is situated chiefly in the left flank, and constitutes the main part of the small intestine. The *large intestine* is much shorter than the small, but of greater capacity. It is divided into two portions—the cæcum and colon. The cæcum, into which opens the ileum, is marked off from the small intestine by the so-called ileo-cæcal valve. It is a large elongated sac ending blindly at one extremity (*CAE*). The cæcum is largely developed in the horse and all other herbivorous animals, containing as much as 6 to 7 gallons of fluid. It is constricted and provided with longitudinal bands of muscle, which on being cut cause the constrictions to disappear.

Close to where the ileum enters the cæcum is another opening, from which springs the colon. The colon is divisible into two regions—the large colon (Co^{i}) and the floating colon (Co^{ii}). This portion of the canal is also constricted at its commencement, the constrictions being much more closely united. The colon forms a loop surrounding the cæcum, and towards the end it gives rise to a straight thin-walled tube, the *rectum* (*R*), which opens to the exterior by the anus. The colon is about

20 feet long, the large colon holding as much as eighteen gallons of fluid.

In connection with the digestive tube are several glands whose products aid the digestion of the food. These glands are as follows: *salivary-glands* (*SL*), opening into the mouth; the *liver* (*L*), opening into the duodenum; and the *pancreas* (*Pa*), opening into the intestine close to the liver-duct. These three glands are spoken of as true glands. There are others—such as the *thyroid*, *thymus*, and *spleen*—which have no opening at all; these are the so-called ductless glands. The salivary glands, of which there are several, are situated in the sides of the mouth and under the tongue; they are branched glands which pour out, by means of their ducts, saliva into the mouth to amalgamate with the food. The liver is the largest gland in the body: it consists of several large red lobes closely applied to the diaphragm and wrapping round part of the stomach. There can be recognised a right and a left lobe, a middle lobe, and the lobe of Spigelii. By separating these lobes of the liver of a cow or sheep you will observe buried in their midst an elongated, green, thin-walled sac, the gall-bladder. This structure is absent in the horse. Close to it can be traced a tube, the *ductus choledochus* or bile-duct (*Bd*), which passes from the liver and runs to the duodenum, into which it opens, —the opening being provided with two flap-like valves, forming the ampulla of Vater. Down this duct the bile runs so as to reach the food. The valves are to stop the flow of food up the bile-duct. In the horse the bile is always flowing into the intestine; in other animals it chiefly flows during digestion—meanwhile it is stored up in the gall-bladder. In the horse the secretion is more rapid during digestion, in spite of its constant flow.

The *pancreas* (*Pa*) or "sweetbread" is a pale pink-coloured gland much lobulated, and lies in a membrane in close relation to the stomach and small intestine. From it there runs off a tube, the pancreatic duct (*Pd*), which opens into the duodenum close to the ampulla of Vater.

The *thyroid* is a gland which is found close to and behind the larynx, beside the two first rings of the trachea. This gland consists of two oval lobes of a reddish-brown colour, united by the so-called "isthmus." It is more important in the young and fœtus than in the adult, and is especially developed in Ruminants and Carnivora. What its functions are we do not definitely know: some say it is to destroy the mucin in the body, others that it is a gland connected with the brain. The former is apparently correct.

The *thymus* is another ductless gland found in the fœtus only, resembling the thyroid, white and lobulated in form, and partly situated in and partly out of the chest.

Closely connected with the sub-lumbar region and the great curvature of the stomach is a large vascular ductless gland, the *spleen*. The spleen in the horse is falciform in shape, violet-blue to red in colour, soft and elastic in texture. This gland is really a floating gland, but is lightly attached by the great omental peritoneum and by a suspensory ligament. It is an organ that varies much in size, even in the same animal, often becoming abnormally large. In the horse it weighs 32 ounces. It is well supplied with blood-vessels, and is almost solid. Curious pale patches are found in the pulp that constitutes the majority of the organ, called *Malpighian corpuscles*, developed in the course of the small splenic arteries. It is partly employed in manufacturing red blood-corpuscles and in destroying the same. Some physiologists look upon it as a swelling or pouch of the portal vein.

The *peritoneum* (fig. 191).—The organs and parts of the alimentary canal are partly supported by a thin membrane, which may be double owing to folding, called the peritoneum. This serous membrane lines the walls of the abdominal cavity, and from thence passes to and around the visceral parts. There are then two kinds of peritoneum—the *parietal* (*Pp*), which is applied to the body wall, and the *visceral* (*Pv*), which supports the internal structures. The chief parts of this visceral peritoneum are the great omentum (*Ge*), the hepato-gastric ligament (*L*), the mesentery (*M*), and the meso-colic mesentery. The omentum is the large fold that connects the stomach with the small intestine (3), and is often laden with fat; the hepato-gastric ligament joins the liver to the stomach; the mesentery supports the colon, and may also contain adipose tissue. Rectum (5), vagina (6), and the bladder (7) are also surrounded by it.

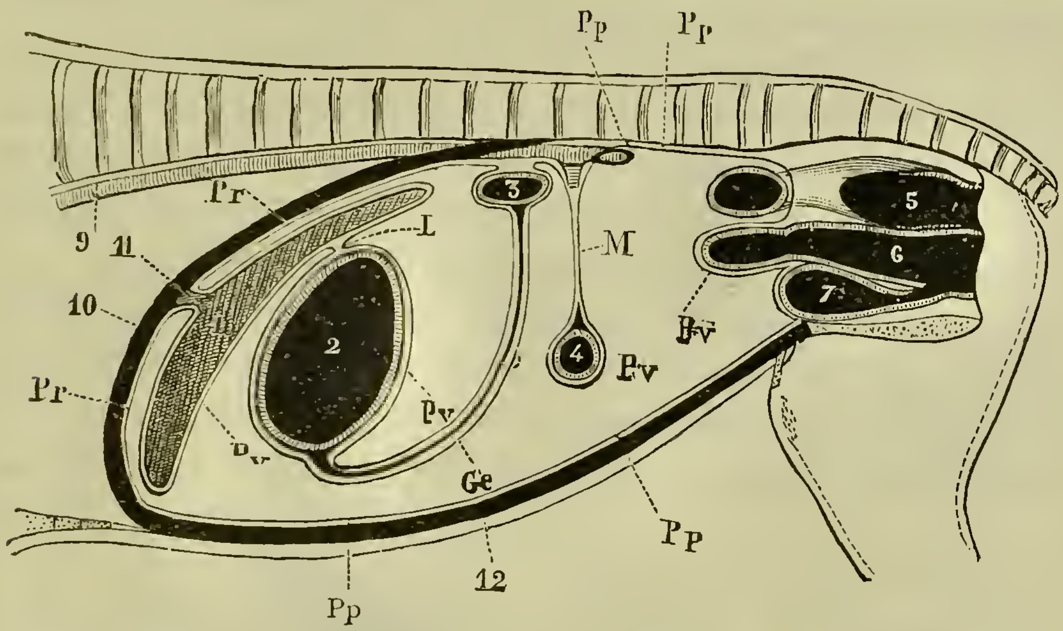

FIG. 191.—THEORETICAL, LONGITUDINAL, AND MEDIAN SECTION OF ABDOMINAL CAVITY, TO SHOW PERITONEUM.

1, Liver; 2, stomach; 3, small intestine; 4, origin of floating colon; 5, rectum; 6, vagina and uterus; 7, bladder; 9, posterior aorta; 10, diaphragm; 11, post vena cava; 12, inferior abdominal wall; *Pp*, *Pp*, parietal peritoneum; *Pv*, *Pv*, visceral peritoneum; *L*, hepato-gastric ligament; *M*, mesentery; *Ge*, great omentum. (Chauveau.)

Situated in the thoracic cavity we shall note two important structures—namely, the lungs and heart (fig. 190, *Lu* and *H*). The *respiratory organs* are absolutely necessary for the maintenance of life, for life requires not only the absorption and assimilation of nutritive matters, but also oxygen from the air to enter into the circulation of these matters. In animals with red blood this element in mixing with the nutritive fluid commences by expelling CO_2, and communicates to that fluid its bright red colour. This produces the combustion that partly forms *animal heat.* It also exercises on the organs a stimulating action, without which the animal tissues cannot manifest their true properties. The organs that carry out this *act of respiration* in mammalia are the lungs. They take in oxygen from the surrounding air and pass out in return CO_2. These organs of respiration, so essential to animal life, are closely shut in, in the thoracic cavity, and are connected with the air by, first, a cartilaginous tube (fig. 192, *Tr*) arising in the back of the pharynx, and, secondly, by the two *nasal cavities.* These latter open into the back of the mouth by two openings, the so-called posterior nares, and to the air by the nostrils.

The whole organs of respiration may be divided into four sections—(1) the nasal cavities; (2) the larynx; (3) trachea and bronchi; (4) the lungs.

In the horse we shall notice very large nostrils: owing to the structure and size of the soft palate (fig. 192, *Sp*) at the back of the mouth, the horse can only breathe through the nasal cavities,

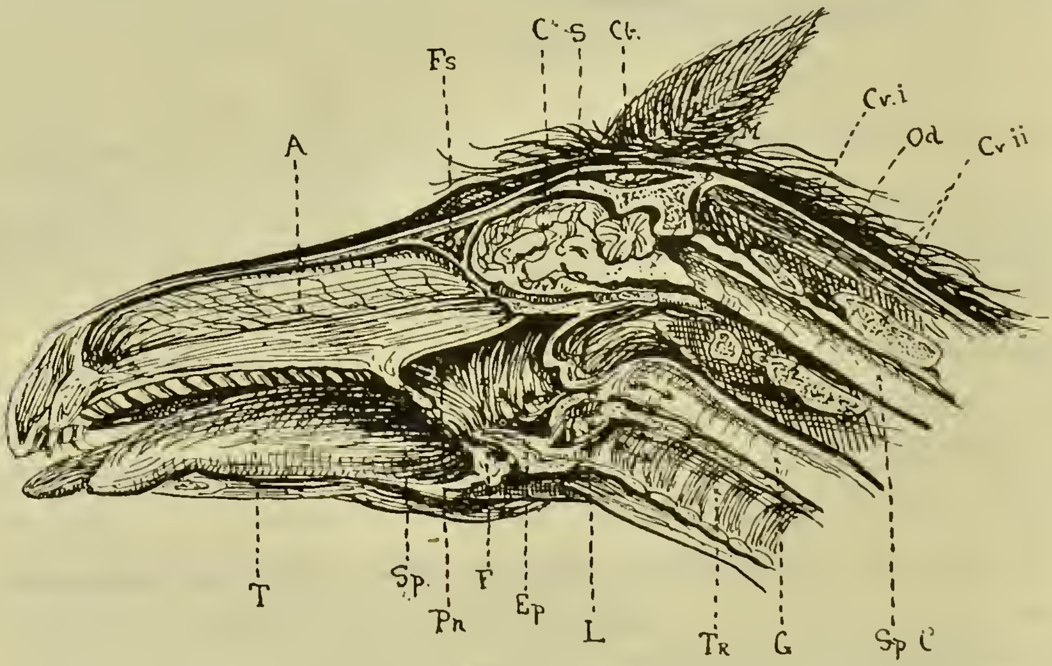

Fig. 192.—Median Longitudinal Section of Head and Upper Part of Neck of Horse. (After Chauveau.)

A, Nasal septum; *T*, tongue, with hard palate above; *Sp*, soft palate; *Fs*, frontal bone and sinus; *Pn*, posterior nares; *Ep*, epiglottis; *C*, cerebrum; *Cb*, cerebellum; *S*, occipital bone; *L*, larynx; *Tr*, trachea; *G*, œsophagus; *Sp.C*, spinal chord; Cv^{i} and Cv^{ii}, atlas and axis.

hence their size. We, however, with a smaller soft palate, *can* breathe through our mouth. The nasal fossæ are lined by a sensitive mucous membrane, part of which is olfactory in function. Closely connected with the nasal cavities are a number of winding spaces excavated in the substance of the bones of the head, on the limits of the cranium and face, and around the ethmoidal masses which they envelop. These cavities form the so-called *sinus* (*Fs*), which increases the area of the skull for the attachment of muscles and for lightening its weight. In the ox the frontal sinus is prolonged into those bony cores that support the horns. Opening from the back of the throat is a slit-like aperture, the *glottis*, partly protected by a flap-like portion, the *epiglottis* (*Ep*). On each side of the opening are placed internally the two vocal cords. These two elastic bands project within the *larynx* (*L*), and between them include the space forming the glottis.

The *larynx* is the organ of voice, and it also admits air during respiration. It is practically a cartilaginous box flattened on each side. Entering into its composition are five pieces of cartilage, numerous muscles, nerves, blood-vessels, and a lining of mucous membrane. This organ dilates and contracts. When paralysis sets in, causing very rapid movements, it produces the so-called "roaring" in horses.

The *trachea* (*Tr*) is a flexible tube arising from the base of the larynx, and is supported by a series of incomplete C-shaped cartilaginous rings. It passes between the two first ribs and enters the chest, arriving above the left auricle to the right of the big blood-vessel, the posterior aorta, where it bifurcates, forming the two *bronchi*. Each bronchial tube divides up in the lungs, sending out an innumerable number of small branches, resembling a tree embedded in the substance of the lung.

The *thorax* or chest, in which the lungs and heart are situated, forms a cavity shut in by the ribs, backbone, diaphragm, and sternum. The thorax is lined by two serous membranes, called the *pleuræ*. Part of these membranes surround the walls of the thorax, part the lungs themselves. There is one pleura on each side. Although the two pleural sacs are apparently distinct, they are no doubt connected by a minute opening in the mediastinum.

The *lungs* are spongy in texture and are two in number, each lying in a separate serous sac. The right lung is larger than the left—the heart being lodged in an excavation between the two. The lungs are very vascular. Blood is sent to them by the pulmonary artery, which carries impure blood to the lungs from the heart: here this impure blood is oxygenated, and sent back to the heart by the pulmonary veins. These are functional vessels: there are also nutrient vessels, the lymphatics, which not only lie around the outer portions of the lungs, but also penetrate the internal lobules.

The organs of excretion, or the *urinary organs*, consist of two *kidneys*, *ureters*, a *bladder*, and *urethral canal*.

The kidneys eliminate the nitrogenous waste from the blood along with water resulting from the exercise of the vital functions. The kidneys are two in number, and are situated in the sub-lumbar region of the body, lying against the great *psoas* muscles. They are enclosed more or less completely in an envelope of cellular fat. Support is also given to the kidneys by the pressure of the organs in the abdominal cavity, and again by the peritoneum, which underlies the urinary organs. The right kidney (fig. 193, *B*) is in front of the left, lying beneath the two last ribs, the left just beyond the last pair. They also vary in shape and size, the right one being heart-shaped, and weighing about twenty-seven ounces; the left one (*A*) is kidney-bean-shaped, and about two ounces less. On one side is a deep notch called the *hilus*. The outside of the kidney is smooth and red in the horse; very different is the kidney of the ox, which is lobulated. From the hilus arises the ureter or tube which conveys the urine from the kidney to the bladder. The ureter (*a* and *b*), which originates in the so-called pelvis of the kidney, is a thin-walled tube about as thick as a goose-quill.

The *bladder* (*D*) is a membranous sac in which the urine is stored up. The pelvic cavity retains this reservoir, which may extend into the abdominal cavity. The ureters open into the lower portion of the bladder, which becomes constricted posteriorly into a kind of neck. In front the sac is rounded, and here may be seen a scar, the spot to which a fœtal structure, the *urachus*, was attached. This urinary sac is united to the pelvis, to the rectum, and to the vesiculæ seminales in the horse, and in the mare to the uterus and vagina. From the neck of the bladder arises the *urethra* (*K* and *L*), which carries away the urine to the exterior. The urethra is also the duct for the genital products in the male, and more or less so in the female. There is thus a connection between the urinary and reproductive organs. They are often spoken of unitedly as the *uro-genital organs.*

The *genital organs* (fig. 193) in the male consist of two glands, the testicles (*E*) and the epididymis (*e*), vas deferens (*F*), vesiculæ seminales (*H*), ejaculatory ducts, urethral canal, prostate (*I*) and Cowper's glands (*J*), the corpus cavernosum (*M*), and the *penis* (*N*). The *testicles* are abdominal in the fœtus, but later descend into a sac, the scrotum, lying at the bottom of this sac and supported by the spermatic cord. These glands, which produce the male cells or spermatozoa, are oval bodies, made up of a large number of lobules, each lobule being composed of two or three long tubes, seminiferous tubes, often over a yard in length. Closely applied to this testis is the elongated *epididymis*, which is made up of from twelve to twenty tubes, united into one twisted tube, from which springs the straight *vas deferens*, a canal as thick as a goose-quill in the horse. Situated just above the bladder are two oval glandular pouches (*H*), in which spermatozoa are stored, and which also add a fluid to the semen. The *ejaculatory duct* is short, and succeeds the narrow canal of the vesicula after the

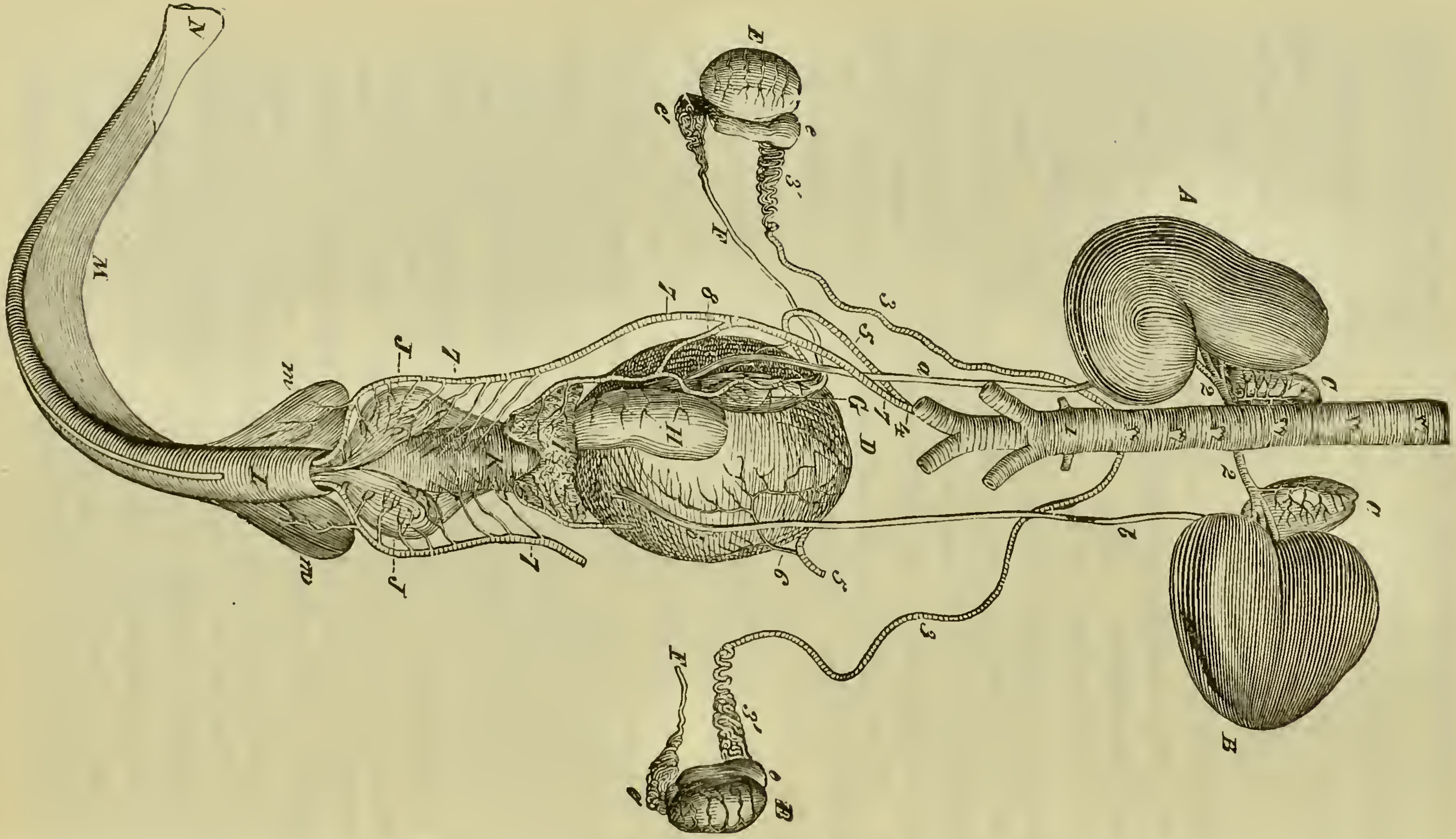

FIG. 193.—URO-GENITAL APPARATUS OF MALE, WITH ARTERIES.

A, Left kidney; B, right kidney; a, b, ureters; C, C, supra-renal capsules; D, bladder; E, E, testicles; c, head of epididymis; c′, tail of ditto; F, deferent canal; G, pelvic dilation of deferent canal; H, left vesicula seminalis; I, prostate; J, Cowper's glands; K, membranous [illegible] urethral canal; L, its bulbous portion; M, cavernous body of penis; m, m, its roots; N, head of penis; 1, abdominal aorta; 2, renal [illegible] vesico-prostatic branch. (Chauveau.)

latter opens into the vas deferens. The *urethra* has erectile walls, and begins at the bladder and ends at the tip of the penis, the erectile tissue commencing towards its end portion. The single *prostate* gland (*I*) lies across the neck of the bladder. *Cowper's glands* (*J*) are two in number: they secrete a fluid which is poured into the urethral canal just before the ejection of the semen. The *corpus cavernosum* is the erectile body which passes up the penis from its base to its tip and supports the urethra. There is considerable variation in the sexual organs of animals, into which we cannot enter.

The female organs (fig. 194), as seen in the mare, consist of two secretory organs, the *ovaries* (3), oval bodies lying just behind the kidneys in the abdomen. The ovaries lie free and detached in the body cavity. Closely applied to them are the oviducts, which expand near the ovaries into funnel-shaped bodies. The oviducts are very small tubes lodged in broad ligaments (4), about as thick as a straw. They open into a large sac, the *uterus* (1 and 2), the space in which the embryo develops. This membranous sac lies in the sub-lumbar cavity of the abdomen, and consists of the body and two so-called "cornua" or horns of the uterus. The cornua pass amongst the intestines, the uterus being supported by the broad ligaments, the rectum (13), and posteriorly by the vagina (16). The inner walls of this cavity are lined by mucous membrane; outside there is a serous layer, and between a thick muscular layer. From the uterus proceeds the *vagina*, a thin tube which terminates in the *vulva* or external orifice. Inside this orifice is found a solid body from two to three inches long in the mare, the *clitoris*, which protrudes into the vulvular cavity, and which is erectile. The ova are dehisced at certain periods, the periods of *menstruation*, "heat," or "rutting."

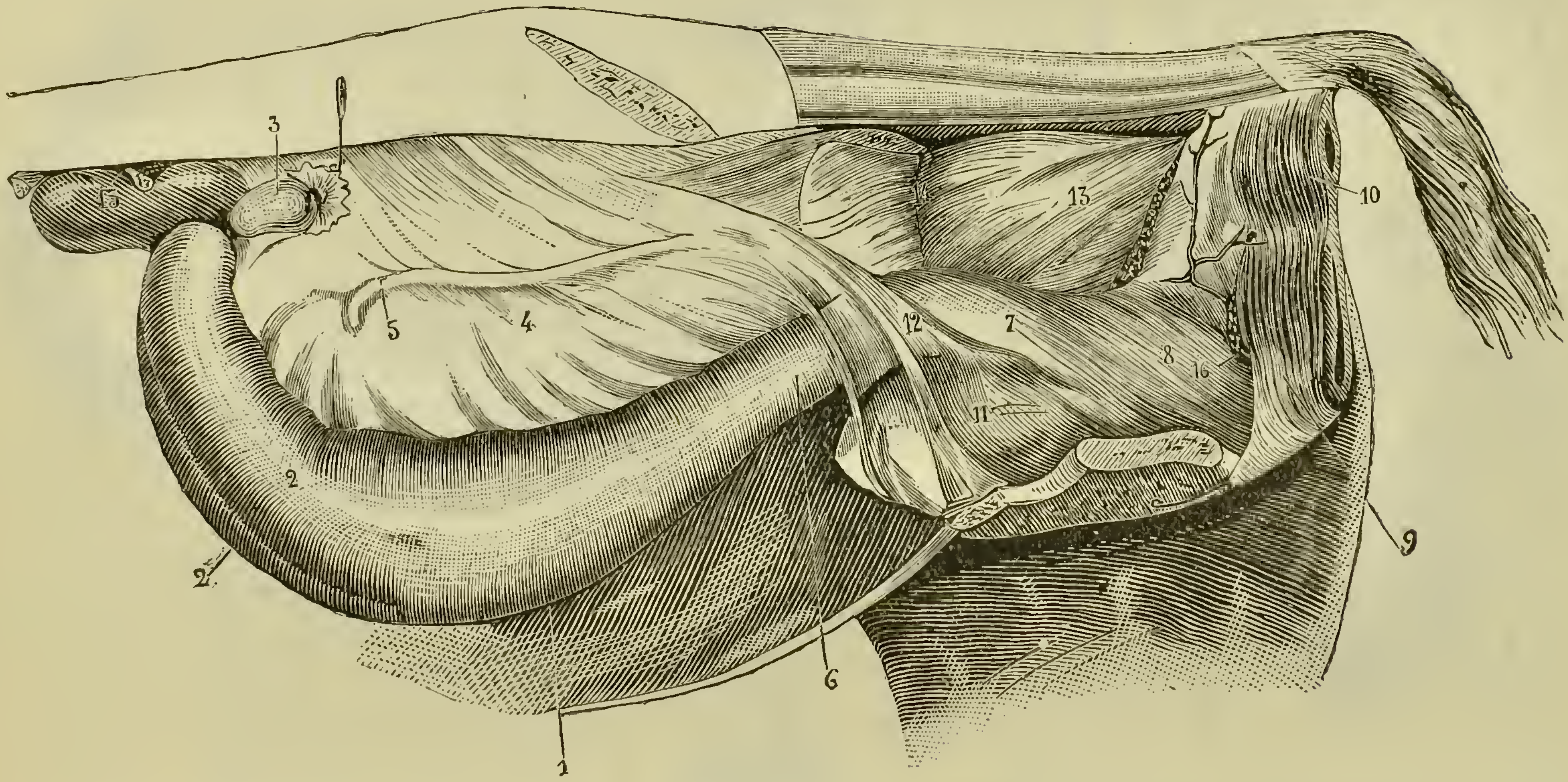

FIG. 194.—GENERATIVE ORGANS OF THE MARE.

1, Body of uterus; 2, cornua; 3, ovary; 4, broad ligament; 5, rudimentary round ligament; 6, cervix uteri; 7, vagina; 8, anterior constrictor of vulva; 9, posterior ditto; 10, sphincter of anus; 11, bladder; 12, ureter; 13, rectum; 14, circular fold of peritoneum surrounding rectum; 15, kidney; 16, bulb of vagina. (Chauveau.)

The Heart and Circulation of the Blood.

The circulatory apparatus consists of a central muscular heart and three sets of vessels.

Two fluids are found in connection with the circulatory apparatus—viz., blood and lymph. Blood is of two kinds, arterial and venous. The former is pure and red, the latter impure and dark. *Lymph* consists of a white to pale yellow fluid, and contains lymph-corpuscles. Intimately connected with this lymph is *chyle.* Chyle is a fluid that comes from the walls of the alimentary canal; it is lymph charged with nutritive matter. Lymph is blood minus the red blood-corpuscles. Chyle is lymph plus fat, &c. We can detect three sets of vessels, as follows: (i) extend from the heart to all parts of the body, and which contain red blood = *arteries;* (ii) pass from all parts of the body to the heart, and which contain dark blood = *veins;* (iii) pass from the majority of organs and walls of intestines to one of the veins = *lymphatic vessels.*

The *heart* is a muscular box, by means of which the blood is circulated or pumped throughout the whole system. The muscle composing the heart is peculiar in structure; it is known as cardiac muscle, and is cubical in form and striated, and of course involuntary in action. The heart lies in a sac closely applied to its walls, the *pericardium,* and is bathed by a fluid, the pericardial fluid. There are four distinct chambers; the two upper are the auricles (fig. 195, *LA* and *RA*), the two lower the ventricles (*V*). The auricles receive the convergent tubes, the veins; the ventricles give origin to the divergent vessels, the arteries. The right and left sides of the heart are quite separate, but the two cavities of each half are in connection, the openings being guarded by valves. The opening from the right auricle into the right ventricle, the "auriculo-ventricular" opening, is closed by the *tricuspid valves,* which consist of three fibro-muscular flaps; the opening between the left auricle and ventricle by the *mitral valve*, which has two flaps only. The auricular portion can be told from the ventricular by an external constriction. From

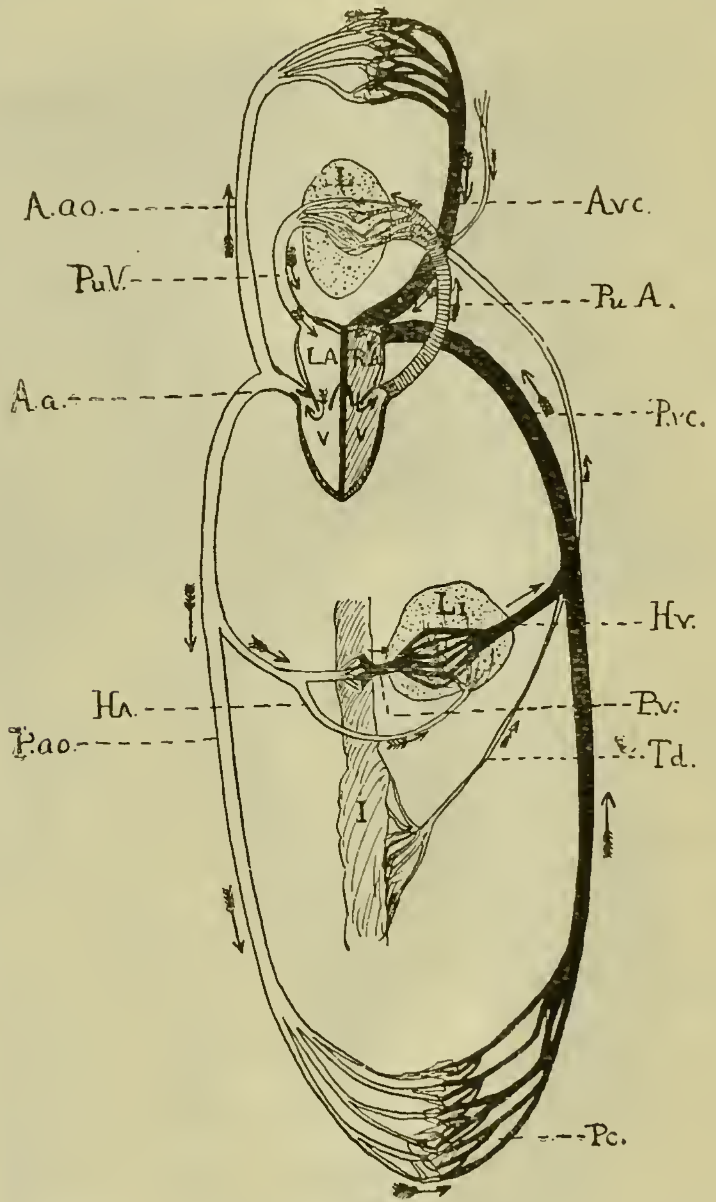

Fig. 195.—Diagram of the Circulation of the Blood.

LA and *RA*, Left and right auricles; *V*, ventricles; *L*, lungs; *Li*, liver; *I*, intestines; *A.vc*, anterior or superior vena cava; *P.vc*, posterior or inferior vena cava; *A.a*, aortic arch; *A.ao*, *P.ao*, anterior and posterior aorta; *Ha*, hepatic artery; *Hv*, hepatic vein; *Pv*, portal vein; *Pu.A*, pulmonary artery; *Pu.V*, pulmonary veins; *Pc*, posterior capillaries; *Td*, thoracic duct.

these chambers arise the blood-vessels. In the right auricle (*RA*) we find three tubes—(i) the *superior vena cava* (*A.vc*); (ii) the *inferior vena cava* (*P.vc*); (iii) numerous small veins from walls of the heart. In the right ventricle we find a vessel, the *pulmonary artery* (*Pu.A*); in the left auricle the *pulmonary veins* (*Pu.V*); and in the left ventricle the opening of the great *aorta* (*A.ao* and *A.a*).

Let us now trace the course of the blood during circulation. The right auricle receives the venous blood from the head, neck, and anterior extremities by the superior vena cava; it also receives venous blood from the lower parts of the body by the inferior vena cava. The right auricle then, holding venous blood, contracts, and by so doing expels the blood through the tricuspid valves into the right ventricle. The right ventricle then empties itself by contracting, the blood being forced through the semi-lunar valves into the pulmonary artery, which carries the venous blood to the lungs; here the artery splits up into a number of minute tubes, the *capillaries*, composed of single-celled walls, thus bringing the red blood-corpuscles in close contact with the air. Another set of capillaries also arise in the lungs; these unite after collecting the blood, and form several pulmonary veins, which carry the blood back to the left auricle. During the passage of the blood through the lungs the venous blood gives up its CO_2, which passes through into the pulmonary alveoli, and so out by the respiratory tubes; at the same time it takes up the oxygen in the inspired air. The venous blood of the pulmonary artery thus becomes converted into arterial blood, carried back by the pulmonary veins to the left auricle. The left auricle when full contracts and drives the arterial blood through the opening and mitral valves into the left ventricle. From the ventricle the arterial blood is pumped into the aorta, which sends one branch to the anterior regions and one to the posterior, carrying the pure blood to the organs and system generally. In the organs, &c., these two large arteries with their minor divisions break up into capillaries, the blood being collected again by other capillaries which unite with the superior and inferior venæ cavæ, and so back to the right auricle, from which we started, the course of the circulation in this way completing its circuit. We thus see that there are two systems—one the "pulmonary system," the other the "systemic" circulation. There is also another system called the "portal" system, which consists of a vein, the *portal vein* (*Pv*), which runs from the walls of the intestine (*I*) to the liver (*Li*). This latter organ is supplied by an artery, the hepatic artery, and a vein, the hepatic vein, besides the portal system. The kidneys have a renal artery and vein coming from the aorta and going to the vena cava.

Lastly, opening into the inferior vena cava near the heart is seen another vessel, the *thoracic duct* (*Td*); this arises in the walls of the intestines in the so-called *lacteal system*, and pours the nutritive fluid derived from the food into the blood-system.

The blood during its passage through the organs oozes through the extremely thin capillary walls. The cells of the organ obtain the nutritive elements from this, and leave behind a watery fluid called lymph. This lymph does not return directly back into the blood, but is drawn away from the organs by a series of tubes which originate as minute blind canals. These lymph-spaces unite into the so-called lymphatic ducts or veins, which, like the blood-veins, are furnished with valves to stop the backward flow of the fluid to the lymph-spaces. Eventually the lymph empties itself into the venous blood-system, and so into the right auricle of the heart. The lacteals and thoracic duct are part of this lymphatic system, but specially modified for the conveyance of the chyle to the blood. This lymphatic system is almost as important as the vascular system, for the blood is partly dependent upon it.

The *sources of blood* are five in number, as follows:—

1. From material absorbed by the lacteals in the primary digestion of food (chyle).

2. From soluble matters—such as water, sugar, and peptones—absorbed by the blood-vessels, and sent first through the liver.

3. From matter formed by certain blood-glands, such as the spleen, &c.

4. From materials derived from the tissues—products of decomposition, and solution of portions of these tissues due to their vital activity (lymph).

5. From a small amount of matter that may be absorbed by the skin.

The blood gives up its waste nitrogenous material in the kidneys; water is also lost by its progress through the same organs, as well as various salts. The skin also yields water and salts derived from the vascular fluid. The CO_2 and aqueous vapour are passed out in the pulmonary sacs, whilst the oxygen is absorbed by the blood in the same area. Blood also loses material during its passage through the organs, &c., for their constructive purposes. This waste is counteracted by the five methods named above, from which the blood is built up and its losses repaired.

The *nervous system* is divided into two distinct portions—the most important being the "central" nervous system, the spinal cord and brain. The other is the "sympathetic" nervous system. The organs of the body are under the control of the nervous system. Muscle and nerve are intimately connected; each muscular act is preceded by a nervous act: sometimes these acts are voluntary, at others involuntary. The movements of the muscles of the limbs, &c., are voluntary acts; the muscular movements of the heart and intestines are involuntary, and yet both are caused by nervous mechanism.

The brain and spinal cord form the central nervous or cerebro-spinal axis. The brain is deposited in the cavity of the skull, the *cranium;* the spinal cord is protected by the bony vertebræ, and lies in the neural canal. The cerebro-spinal axis is surrounded by three membranes—the *dura-mater*, the *arachnoid*, and the *pia-mater*. The dura-mater forms the external layer next the bone of the skull; the arachnoid is a serous layer; whilst the pia-mater closely invests the brain and nervous axis, forming a nutrient membrane. The brain varies much in weight in different animals: in the horse its normal

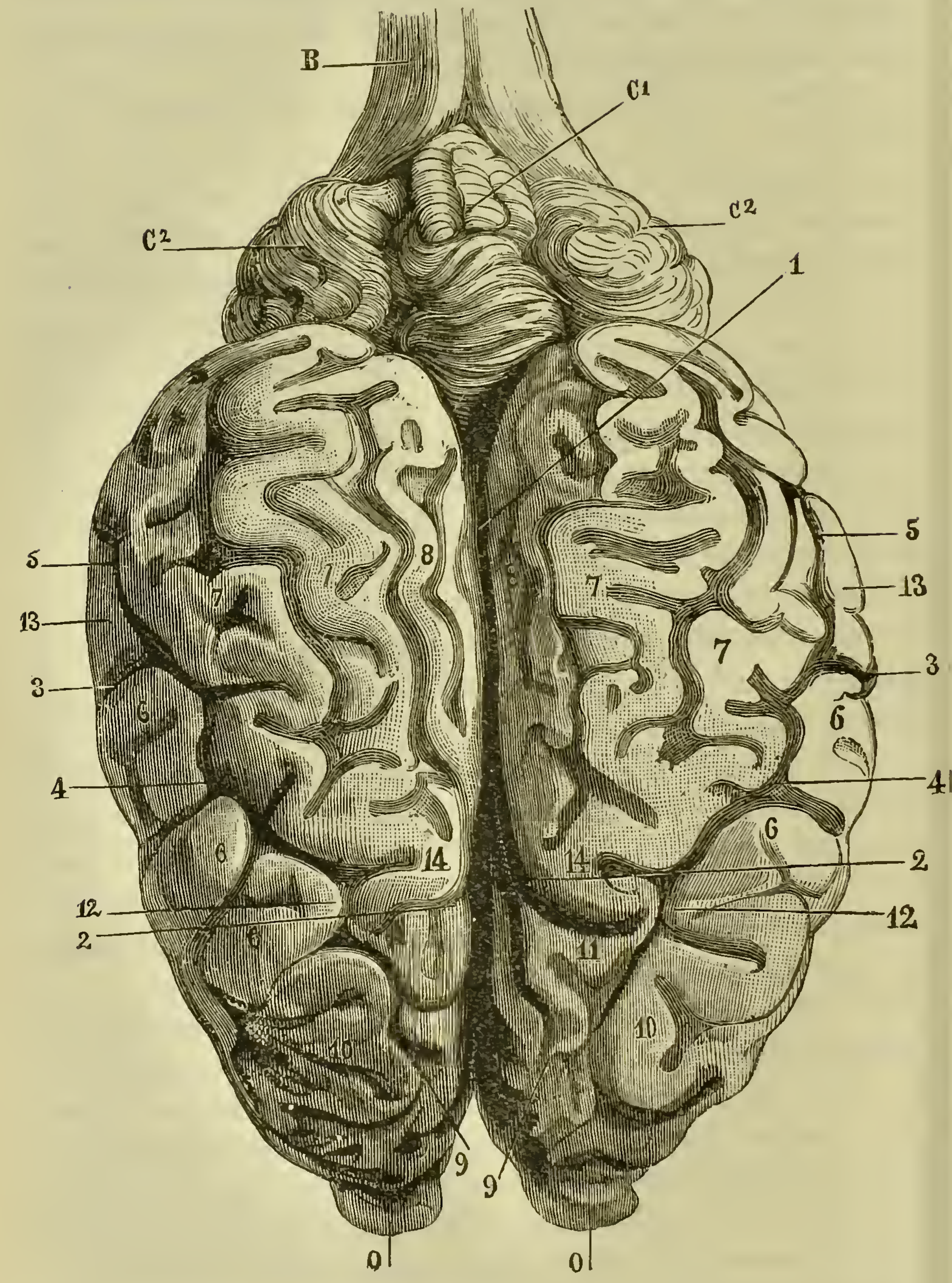

Fig. 196.—Brain of Horse (dorsal view), ¾ nat. size.

B, Medulla oblongata; C^1, middle lobe of cerebellum; C^2, lateral lobes of cerebellum; *O*, olfactory lobes; 1, great longitudinal fissure of cerebrum; 2-14, fissures and convolutions of the cerebral hemispheres. (Chauveau.)

weight is about twenty-two ounces, in the sheep about five ounces. It is ovoid in shape. Viewed on its superior surface (fig. 196), we shall see the following areas, starting from behind, where it joins the spinal cord: The *medulla* or *isthmus* (*B*), a kind of white peduncle running into the brain, the prolongation as it were of the spinal cord: following this is a grey trilobed

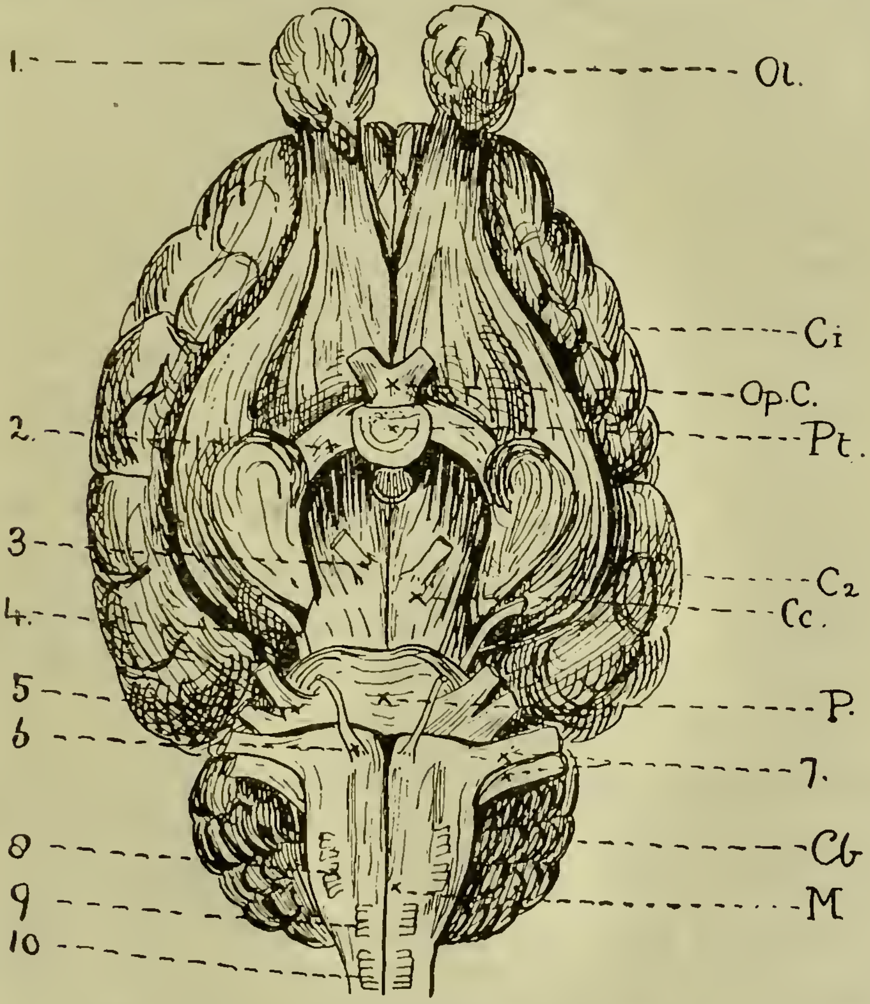

FIG. 197.—BRAIN OF HORSE (ventral view).

Ol, Olfactory lobes; *C*1 and *C*2, cerebrum; *Cb*, cerebellum; *M*, medulla; *Op.C*, optic chiasma; Pt, pituitary gland; *Cc*, crura cerebri; *P*, pons Varolii; 1-10, roots of cranial nerves.

mass, the *cerebellum* (*C*), and in front of the cerebellum are seen two other lobes separated by a deep fissure from the cerebellum and from one another (1); these two lobes are the cerebral lobes, the whole forming the *cerebrum* (2–14). The cerebral hemispheres are more or less convoluted. On examining the undersurface of the brain (fig. 197) it will be seen that the peduncle runs through the base of the cerebellum and enters the cerebral hemispheres close behind two thick white cords, the optic nerves (*Op.C*). Further portions of the isthmus and other parts of the brain are named in the figure (fig. 197).

Both from the brain and spinal cord nerves are given off to the various parts of the body. Those coming from the brain are called *cranial nerves*, those from the spinal cord *spinal nerves;* both groups are always paired. There are twelve pairs of "cranials," as follows:—

1st pair	Olfactory nerves (fig. 164, 1).
2nd "	Optic nerves (2).
3rd "	Oculo-motor nerves (3).
4th "	Trochlear nerves (4).
5th "	Trigeminal nerves (5).
6th "	External oculo-motor nerves (6).
7th "	Facial nerves (7).
8th "	Auditory nerves (8).
9th "	Glosso-pharyngeal nerves (9).
10th "	Vagus or pneumogastric nerves (10).
11th "	Accessory nerves (10).
12th "	Hypoglossal nerves.

The olfactory constitute the olfactory lobes in the brain; they pass to the nose and form the sense of smell (fig. 197, *Ol*). They arise from two roots at the brain. Impressions of odours are received by them and are transmitted to the brain. The optics are, of course, the nerves of sight: they cross one another and form the optic chiasma (fig. 197, *Op.C*). The third and fourth pairs are for the movements of the eyes. The trigeminal are a very large pair, have many branches, and are connected with the sympathetic system. They arise by two roots, one sensory, while the other contains motor fibres, there being a ganglion on the sensory root. The sixth arises by five to eight roots from the medulla, and also supplies the eye-muscles. The facial nerves are motor in origin, but receive sensory fibres; they excite the contraction of the muscles of the face in general and some of the salivary glands; they are vaso-motory and excito-secretory in function. The auditory are the nerves of hearing; they spring from the medulla by two roots. The ninth pair go to the tongue and take part in the sense of taste. The vagus is the most important; it has both sensory and motor roots, and supplies the stomach and respiratory organs. The eleventh arises with the vagus and supplies the intercostal muscles. The last, the hypoglossals, again, supply the tongue, acting on the lingual muscles.

The *spinal nerves.* The spinal nerves leave the vertebral canal by the intervertebral foramina and proceed to the various organs. There are forty-two or forty-three pairs, as follows: eight cervical pairs, seventeen dorsal pairs, six lumbar, and five sacral; the coccygeal vary from six to seven pairs. The spinal nerves differ from the cranial in that they all resemble one another at their origin. There are always two roots, one being motor, the other sensory, in function. The two roots unite into a thick trunk in passing through the foramina of the vertebræ, and then divide again into two branches, the superior branch going to the spinal muscles and integuments covering them, the inferior branch passing to the lateral and lower parts of the trunk or to the limbs. All send from their inferior branch one or more nerves to form the great sympathetic system. On the face of the sensory root is found a ganglion. The superior branches of the cervicals go to the oblique muscles of the head, the cervical muscles, and here they anastomose, forming a kind of network, the *cervical plexus.* The inferior branches cover the anterior lateral parts of the neck and muscles of the breast, and form another plexus, the *superficial cervical plexus.* The last two mix with those of the dorsal region, and form the *brachial plexus.* The dorsal nerves send their superior branches to the muscles and skin of the dorsal lumbar region, their inferior branches to the pleuræ and intercostal muscles. The lumbar send the superior branches to the spinal muscles and the integument of the loins and croup; the inferior branches to the muscles of the abdomen and muscles of the flank, to the testes and "stifle-joint"; and the last two form a plexus. The sacral send their superior branches to the muscles at the side of the sacrum, and their inferior branches to the pelvic cavity, and to the anus and penis. The coccygeal supply the tail.

The *sympathetic nervous system* consists of a number of ganglia which are detached from the central nervous system but connected with it by nerve-fibres. This nervous system consists of a chain of ganglia on each side of the spinal cord. This system controls the vascular system, and thus affects animal heat: it is also connected with involuntary muscular action.

CHAPTER XIII.

CLASSIFICATION OF THE CRANIOTA.

A. THE ICHTHYOPSIDA.

THE Craniota are divided into five great classes—the *Pisces*, *Amphibia*, *Reptilia*, *Aves*, and *Mammalia*. There are two ways of classifying these five sections. One was formulated by the late Professor Owen, who divided them into two primary sections, the *Hæmatocrya* and the *Hæmatotherma*, the distinctive features being taken from the blood. The *Hæmatocrya*, or the Fish, Amphibia, and Reptilia, have an imperfect circulatory system, there never being four distinct chambers to the heart. These are called Cold-blooded Animals. The *Hæmatotherma* are the Aves and Mammalia, in which we always find four distinct chambers to the heart and a complete pulmonary and systemic circulation. Circulation is rapid. These are the Warm-blooded Animals. This division is an unnatural one; for we find placed in the two separate groups the Birds and Reptilia, which to a certain extent interlace when we examine the fossil species in the rocks, and which even in existing forms present some analogous structural features.

Huxley divided the Craniota into three sections, as follows:—

A. **Ichthyopsida** = Fish and Amphibia.—These have always gills or branchiæ at some period of their life, and their blood-corpuscles are nucleated. The embryo has never that fœtal membrane called the amnion, and the allantois when present is only rudimentary. Diaphragm absent.

B. **Sauropsida** = Birds and Reptiles.—There are never found branchiæ in either of these classes, and the embryo is provided with both an amnion and allantoic membrane. The red blood-corpuscles are nucleated, and the skull always articulates with the vertebral column by a single occipital condyle, whilst the lower jaw has always a bone between it and the skull called the *quadrate bone.* Diaphragm never complete.

C. **Mammalia** = Mammals.—These have always two condyles on the skull for articulating with the vertebral column. The lower jaw, which is composed of two bones only, articulates, as we saw in the skeleton of the horse, direct with the skull, the quadrate bone not being present in its normal position. In mammals it has become attached to the auditory apparatus. Lastly, there are always developed in the female special ventral glands—the mammary glands—for the nourishment of the young. Diaphragm forming a complete septum.

A. ICHTHYOPSIDA.

I. PISCES OR FISH.

Fish are aquatic vertebrate animals which breathe entirely by means of gills (except in a few curious specially modified species, such as the Climbing Perch, *Anabas*). The gills are covered by a

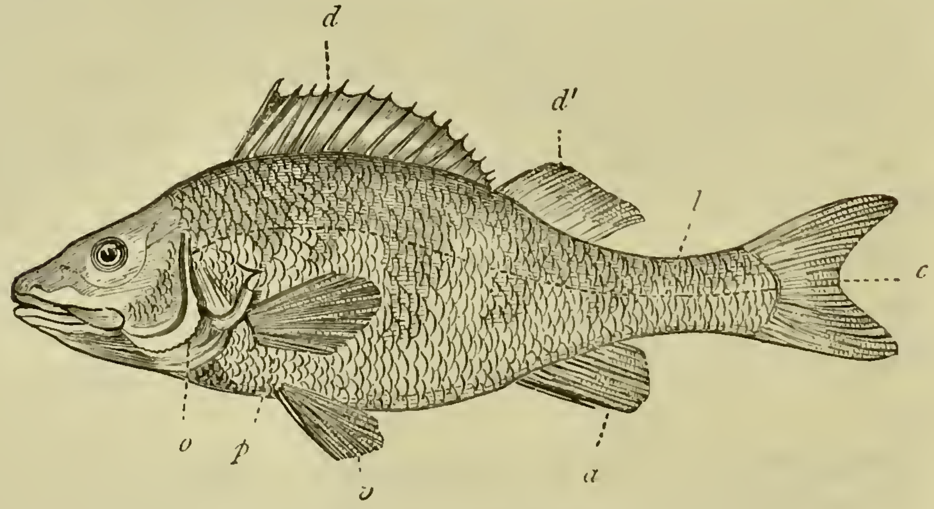

FIG. 198.—THE PERCH (*Perca fluviatilis*), a Teleostean.

p, Paired pectoral fins; *v*, paired pelvic fins; *d* and *d′*, dorsal fins; *c*, caudal fin; *a*, anal fin; *o*, operculum; *l*, lateral line. (Nicholson.)

bony plate, the *operculum* (fig. 198, *o*). The limbs when present are represented by fins; and the heart, except in one group, the Dipnoi, consists of two chambers only, a single auricle and a ventricle. The blood runs back from the body into the auricle (*a*), and from thence through the ventricle it is sent to the gills (*b*) to be purified. From the gills it runs on as arterial blood to the various parts of the body. The blood is only pumped to the gills; thus the heart is a purely respiratory one. A skeleton is always present, either bony or cartilaginous. In the lowest fishes—Sharks, Rays, &c.—it is cartilaginous; in the more highly developed fish—*Teleostei*—it is bony. The sexes are always distinct, ova or spawn being deposited by the females. The young fish or "fry" are like the parent; but a few, such as the Lampreys, have a kind of metamorphic development. The embryonic fish has no amnion, and the allantois, which is represented by the urinary bladder, is always rudimentary. *Most* fish are covered by scales, which are formed by the dermal or under layer of the skin. The vertebræ are always biconcave or amphicœlous, the concavities being filled in with notochordal matter. In the cartilaginous fishes, such as the sharks, we can see the vertebræ being drawn into the skull to take part in its formation. As, with one or two exceptions, fishes are aquatic creatures, and as they are of no importance agriculturally (except as manure [1]), we may thus summarily dismiss them.

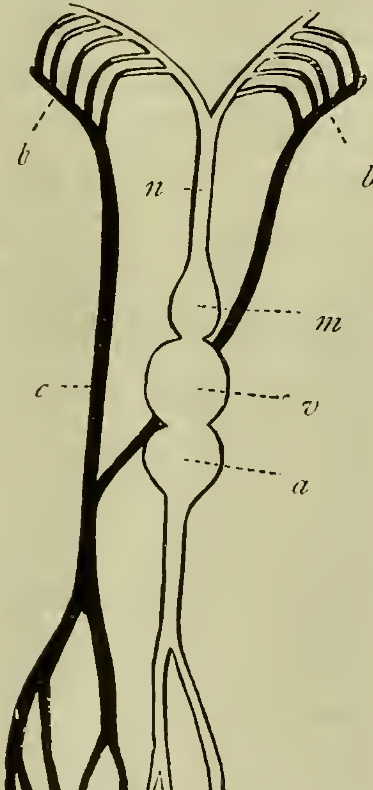

FIG. 199.—DIAGRAM OF THE CIRCULATION IN FISHES.

a, Auricle; *v*, ventricle; *m*, bulbus arteriosus; *n*, branchial artery; *b*, vessels in gills; *c*, aorta. (Nicholson.)

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[1] Fish are often used as manure in hop-gardens, &c., in littoral regions when there has been a large glut on the market.

II. AMPHIBIA (*Frogs, Toads, and Newts*).

Amphibia include the Frogs, Toads, Water-Newts, &c. These must claim our attention for a while, as all three are of much service to us as a means of keeping in check many noxious insects, not to mention slugs, snails, and other so-called vermin.

Amphibia resemble fishes in that they always have gills during some part of their life; but, as a rule, these gills are not persistent. On the other hand, Amphibia have generally *lungs* in the adult form, and their limbs are never in the form of fins as in the Pisces; even the median fin-like structure seen in Salamanders and Newts (fig. 201) is not a true fin, for there are no fin-rays such as we find in fish. The limbs, in fact, approximate in structure to those of the higher vertebrates, whilst the skull always articulates by two occipital condyles with the spinal column. The heart also differs from the heart of fish, for it consists of three chambers — namely, two auricles and one ventricle.[1] On dissecting a frog, which can be taken as the best type, one will at once observe that the rectum, ureters, and the ducts of the reproductive organs open into one common chamber, the so-called *cloaca*.

Lastly, the Amphibia develop by a metamorphosis, sometimes very marked, at others obscure, but always present. The larvæ are provided with gills, which usually disappear, giving place to lungs, in the adults. Some Amphibia do retain the gills persistently, such as the remarkable Axolotl (*Siredon pisciforme*) of the Mexican lakes, which may attain the adult stage whilst still retaining its gills. In captivity, as the author has found in two cases, the Axolotl may lose its branchiæ and become terrestrial under forced circumstances; whilst other ova of a similar brood kept at the Brighton Aquarium remained with persistent gills.

The two chief groups of Amphibia are the *Urodela* and *Anoura*.

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[1] The Dipnoid fish have a small second auricle. These so-called "Mud-fish" of Africa and S. America are transitional between Fish and Amphibia

The *Urodela* are the Tailed Amphibia, the larval tail being retained throughout life: they have a smooth naked skin and a compressed or cylindrical tail, and their vertebræ are both amphicœlous and opisthocœlous. To this division belong the Tritons or Water Salamanders or Newts, and the true Land Salamanders. The *Anoura* are the Frogs and Toads, or the Tailless Amphibia, which are destitute of gills in the adult state, and always devoid of a tail; both structures, however, are present in the larva. Anoura have always two pairs of limbs, procœlous dorsal vertebræ with large transverse processes, serving the functions of ribs, which are absent. The radius and ulna and the tibia and fibula are anchylosed together. The posterior limbs, which are the larger, have usually the feet webbed and adapted for swimming. The heart of the Amphibian is a stage higher than that of fishes. Although it is composed of three chambers, two auricles and one ventricle, in the adult, the larval heart is the same as in fishes. The blood in the adult is received from the lungs in the left auricle and from the body in the right auricle, both emptying into the single ventricle, which therefore contains mixed arterial and venous blood, and this mixed blood is pumped to both the lungs and system. The larva has only a two-chambered heart, the blood being driven to the gills, through them, and on to the system; but as the gills begin to give place to lungs, little branches pass off from the branchial vessels, which unite as the lungs increase and carry part of the blood to the pulmonary sacs. Eventually the gill supply may cease, the entire blood going to the lungs, when we get a third chamber formed in the heart in the form of another auricle. Other Amphibia have both branchial and pulmonary supplies permanent. The blood-supply then being mixed, oxygenation is comparatively slow, and thus little heat is generated, the Amphibia, like fishes, being cold-blooded vertebrates.

The development of an amphibian is best seen in the frog. The spawn, which is deposited in masses in the water, is surrounded by gelatinous discs, the black ovum (fig. 200, 1) being seen as a small round body in the middle. The young (3) when hatched and free from the gelatinous envelope attach themselves by two suckers to the jelly of the spawn. The young Tadpoles are very like "tailed amphibia," and in their earliest stage have both internal and external gills (4). The tail is long, thin, an fish-like, but there are no fin-rays. The external gills soon dis appear. The upper and lower jaws become hardened, and for a kind of beak. By degrees small bud-like outgrowths appea between the body and tail, which grow out into the hind-lim (6), which are always the first to appear in the Frogs and Toad

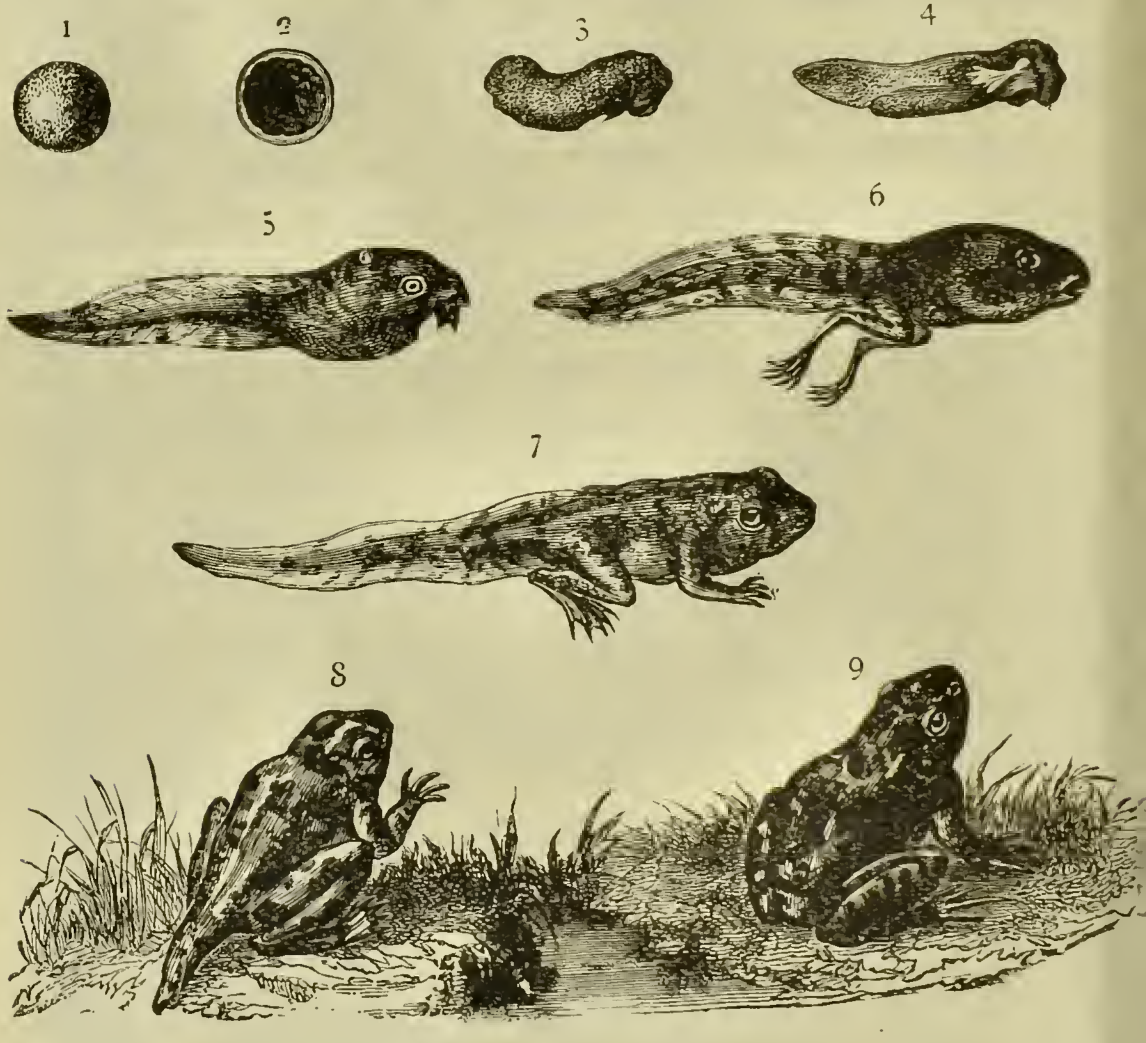


Fig. 200.—Development of the Frog.

1 and 2, Ova; 3-5, tadpoles; 6, period when first pair of legs form (posterior pair) 7, both pairs of legs present (Urodela stage); 8, tail disappearing; 9, adult fro (Nicholson.)

The front limbs are formed later as buds in the branchial cavities. The next stage of the tadpole is just like a tailed amphibian: the tadpole tail still exists with the four limbs, as we see in the newt (7). During this metamorphosis more and more of the blood-supply is passed to the pulmonary sacs as the larva develops, and when the adult stage is reached, and the creature becomes purely aërial and terrestrial, all sign of the branchial circulation has become obliterated by a gradual process of elimination. The tail eventually disappears (8, 9).

The adult Anoura are all fond of damp situations. Their skin is moist. The adults always feed upon insects, slugs, worms, &c. *Anoura* or Tailless Amphibia have a soft skin, with rarely any trace of exoskeleton. The two chief groups are the *Bufonidæ* or Toads and the *Ranidæ* or Frogs. The Toads have no teeth in their jaws, and always a tongue. The hind-limbs are not so very abnormally developed, the toes being only imperfectly webbed; the toes of the forefeet are always free, and the skin is rough and granulated. The two English species are the Common Toad (*Bufo vulgaris*) and the Natterjack (*B. calamita*). The latter, which is a large toad, is somewhat local. *Bufo vulgaris* is a most beneficial animal: when kept in greenhouses it does an enormous amount of good, clearing off slugs, snails, and other vermin of a night.

The Toad catches its prey only when it is moving. The tongue is then thrown forward, and picks up the fly on its tip and returns it to the throat. Toads live to a great age. The development is much like that of the Frog, but the eggs are laid in two long strings, the ova being surrounded by a gelatinous substance and placed alternately. Sometimes these strings of eggs reach four feet in length. They hatch out later than Frogs, the larvæ not maturing until August or September.

The Natterjack can be told by having a pale line down the back. Unlike the Common Toad, it is quite active and often go in pairs. It is found in dry places, only going to the water to breed. In places where it occurs it is often common. At one time the Natterjack was common in many localities around London. It can at once be told by its olive tint, darkened on the flanks with a marked pale yellow stripe running down the back, the under parts yellow, with black spots, and there are dark bands on the legs. The warts on the dorsum are reddish-brown.

In the *Ranidæ* or Frogs the upper jaw carries teeth. The hind-legs are enormously developed and adapted for leaping, the toes always webbed; the toes of the fore-limbs are free. The Common Frog (*Rana temporaria*), which is our common species, is found over nearly the whole of Europe, North Asia, North Africa, and North America. The adults hibernate in all manner of moist situations—especially in mud, in dykes, and pools— until the spring, when they come forth and soon commence to breed and to deposit the gelatinous spawn in large masses in the water. The development and growth of the tadpole have bee previously described.

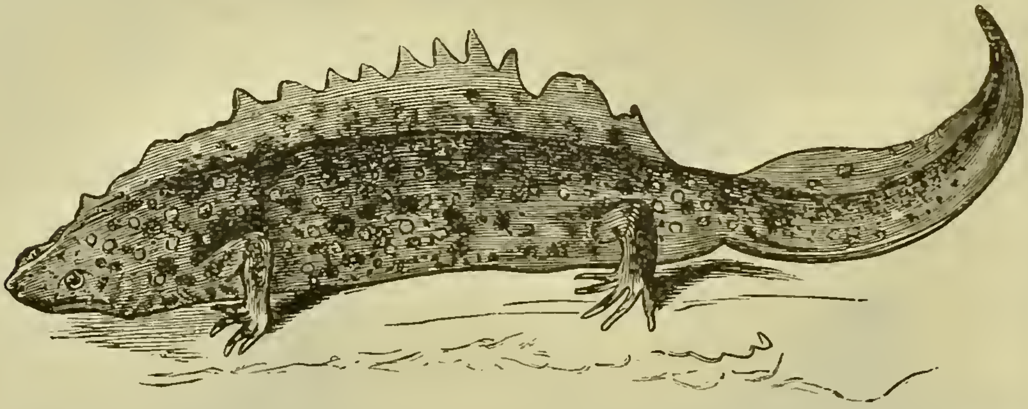


FIG. 201.—MALE CRESTED NEWT (*Triton cristatus*). (Nicholson.)

The Frog often wanders far from water, but they must hav a certain amount of damp to flourish. They are most beneficia in gardens, feeding off all kinds of vermin, and should b encouraged with the Toad.

Amongst the *Urodela* we have in Britain two well-know species, the Great Crested Newt (*Triton cristatus*) and th Common Newt or "Eft" (*Lissotriton tæniatus*). The Wate Salamanders or Tritons have a compressed fish-like tail, an breathe only by lungs. The tongue is small and free, and the mouth is provided with two rows of teeth. There will be observed, if we examine a crested newt, to be four toes only to each foot in front and five on each foot behind. All water-newts produce oviparously, and the males can be distinguished by having a large dorsal crest on the back and tail. This crest appears during the breeding season, and partly goes as soon as it is over. Newts develop very similarly to frogs; but they retain their larval tail, and the fore-limbs always appear before the hind-limbs. The eggs are laid singly on water-plants, often surrounded by the leaf. Like toads and frogs they live upon many noxious creatures.

Two other species of Newts are recorded as British—namely, the Palmate Newt[1] (*Lophinus palmatus*, Dum. and Bibr.), and Gray's Banded Newt (*Ommatotriton vittatus*, Gray), according to Cooke.[2] The former is recorded from Edinburgh and the Pentland Hills. The latter was found near London.

[1] 'Zoologist,' May 3, 1848. J. Wooley.

[2] 'Our Reptiles and Batrachians.' M. C. Cooke. P. 168. 1903.

CHAPTER XIV.

B. SAUROPSIDA.

I. Reptiles.

The Sauropsida are the Reptiles and Birds,—the *Reptilia* and *Aves.* Although there seems much difference between a snake and a fowl, yet we can even in such extremes find some points of resemblance. Much greater is this affinity to be seen when we examine extinct forms of life ; for amongst these ancient remains of the past life of the globe are found many transitional forms between the snake and the bird. These two groups are united together because the resemblances between them are greater and more fundamental than those between either of these groups and the Mammals on the one hand and the Amphibia on the other. Sauropsida, like Mammals, never breathe by means of gills at any period of their life. They always have, as we shall see in the Embryology of the Fowl, a distinct amnion and allantois in the embryo—two fœtal membranes also found in the Mammalia ; the red blood-corpuscles are also always nucleated. In the skeleton we see many characters common to both Birds and Reptiles, especially the presence of the *quadrate* bone and the single occipital condyle in the skull.

Reptilia (*Snakes, Lizards, &c.*)

The Snakes are of little or no importance to us, as they are not in any way directly connected with agriculture in this country, and are nowhere in such abundance as to be a serious nuisance to man. Nevertheless, as one British species, the Adder (*Vipera berus*), is poisonous, it is as well that we should refer very briefly to them. Lizards, however, are decidedly beneficial, for they feed upon noxious insects, &c. Reptiles are all provided with a bony skeleton, and may or may not possess legs. The heart is composed of four chambers; but the two ventricles are not completely separate, except in the Crocodiles. The heart (fig. 202) functionally only consists of three chambers, although we have an advance towards the typical completely four-chambered organ. The circulation in Reptiles is as follows: the impure blood is returned from the body by the large veins (*c*) and emptied into the right auricle (*a*); from the auricle it passes on to the ventricle (*v*). The pure arterial blood from the lungs enters into the left auricle (*a′*) and then into the ventricle. Thus the ventricle with its incomplete septum contains mixed blood much as in the frog, this mixed blood being sent by the ventricle to the lungs by the pulmonary artery (*p*) and to the body by the aorta (*o*). We thus get a stage higher than in the Amphibia. Reptiles, then, like Amphibia, are cold-blooded animals of sluggish habits. They reproduce like Birds, oviparously, the eggs being often laid in strings; the shells may be hard, but are sometimes soft. All the Crocodilia and most Tortoises lay eggs with a shell just as thick and hard as that of birds. Reptile eggs are incubated by the heat of the sun or by the warmth generated by decaying vegetation in which they are often laid. A few cases of an ovoviviparous nature occur,—for

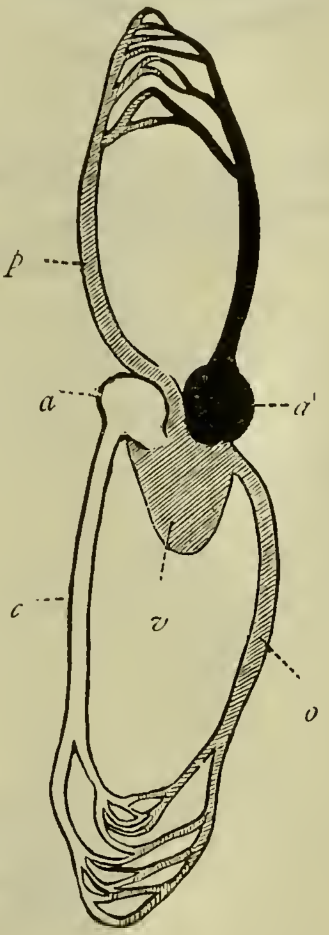


FIG. 202.—DIAGRAM OF THE CIRCULATION IN REPTILES.

a, Right auricle; *a′*, left auricle; *v*, arterio-venous ventricle; *p*, pulmonary artery; *o*, aorta. (Nicholson.)

instance, the Common English Adder, which may retain the ova in the uterus until they are incubated.

Many Reptilia are provided with numerous teeth, some being connected with poisonous glands at their base (fig. 204, D). The poison-fangs have a tube running up them, through which the poison is ejected when the snake bites. Teeth of reptiles, except in the Crocodiles (fig. 203, i and ii), are not lodged in sockets, as we see is the case in the Mammalia, but are implanted in one long groove near the edge of the jaw.

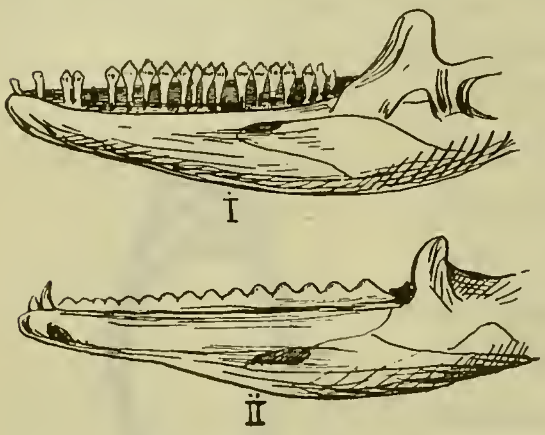


Fig. 203. —Pleurodont and Acrodont Dentition.

i, Pleurodont dentition (in crocodiles, &c.); ii, acrodont dentition (note teeth anchylosed to the bone). (Brit. Mus. Guide.)

There are four existing groups of Reptiles — namely, the *Chelonia*, or Tortoises and Turtles; the *Lacertilia*, or Lizards; the *Ophidia*, or Snakes; and the *Crocodilia*, or Crocodiles and Alligators. Numerous extinct forms are found in the Mesozoic or Secondary rocks, a period of the earth which was characterised by the abundant and extravagant forms of reptilian life. The British Reptilia are

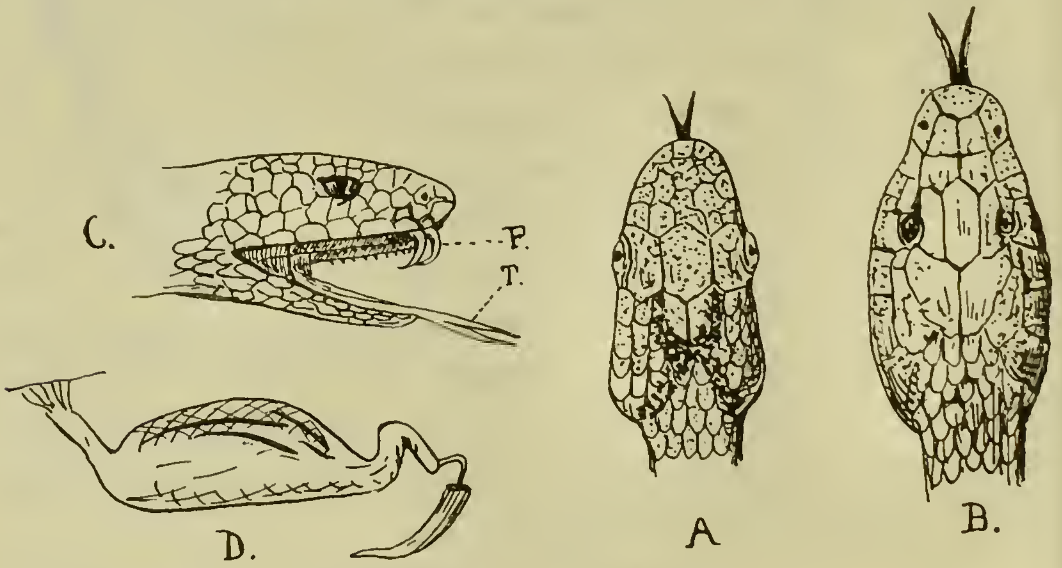


Fig. 204.—Head of Reptiles.

A, Head of adder; *B*, of grass-snake; *C*, side view of *A*; *P*, poison fangs; *T*, tongue. *D*, poison-bag and fang.

not numerous: they include three species of snakes, namely, the Adder (*Vipera berus*), the Grass-snake (*Tropidonotus natrix*), and the Smooth Snake (*Coronella lævis*)—and some Lizards (*Lacertilia*), namely, the Blind-worm (*Anguis fragilis*), the Common Lizard (*Lacerta vivipara*), the Sand Lizard (*L. agilis*), and the Green Lizard (*L. viridis*).

The Adder (*Vipera berus*) can be easily told from the Grass-snake. It has a broad head, and varies in colour from greenish-grey to deep chestnut-brown, with a dark band of lozenge-shaped patches down the dorsal side of the body. Sometimes entire black specimens may be found on the North Downs. In length the adder may attain as much as thirty-two inches. The two poison-fangs are well developed (fig. 204, C): through them, by a small canal in each, the poison is poured into the wound they cause, which never seems to bleed. Very few instances of the adder bite have proved fatal, nevertheless the poison causes much pain and violent inflammation and swelling in the poisoned region, which may last for some considerable time. Adders are particularly fond of hillsides and heathy tracts, especially where the sun strikes with much warmth. They look after their young for a little while. Often the young are produced alive. The food of adders consists chiefly of frogs and mice. Strong ammonia rubbed into the wound is one of the best remedies for the bite.

The Grass or Ringed Snake (*Tropidonotus natrix*) (fig. 204, B) is longer than the adder: they have been seen over three feet in length. It is bluish in colour, with black and creamy-white marks on the ventral surface, and with a yellow and black band across the neck. The eggs are laid in strings in sandy and dry places, and incubate by the heat of the sun; they are also often buried in leaves, which hastens their development.

The Brown or Smooth Snake (*Coronella lævis*) is from about one and a half to two feet long, brown in colour, with dark-brown patches on the back and with a dark-brown head. They are not very common, and feed chiefly on Lacertilia.

The Blind-worm or Slow-worm (*Anguis fragilis*) (fig. 205), although snake-like, is a true lizard (*Lacertilia*), but devoid of limbs. Why it is called the Blind-worm is unaccountable, for it has well-developed eyes. The habits of this snake-like Lizard are very interesting. They appear from their winter quarters long before the Snakes and Amphibia. In the winter they bury themselves in galleries in the earth beneath heaps of leaves and in banks. The chief food consists of slugs and worms, which they take in a very leisurely manner. The young are very pretty — shining creamy yellow above, black below ; a black line also running down the back which expands over the head. They vary from nine to twelve or more at a birth. When frightened they can readily cast off their tail, which seems to retain vitality some time after severance from the body. The Sand Lizard's tail breaks off similarly.

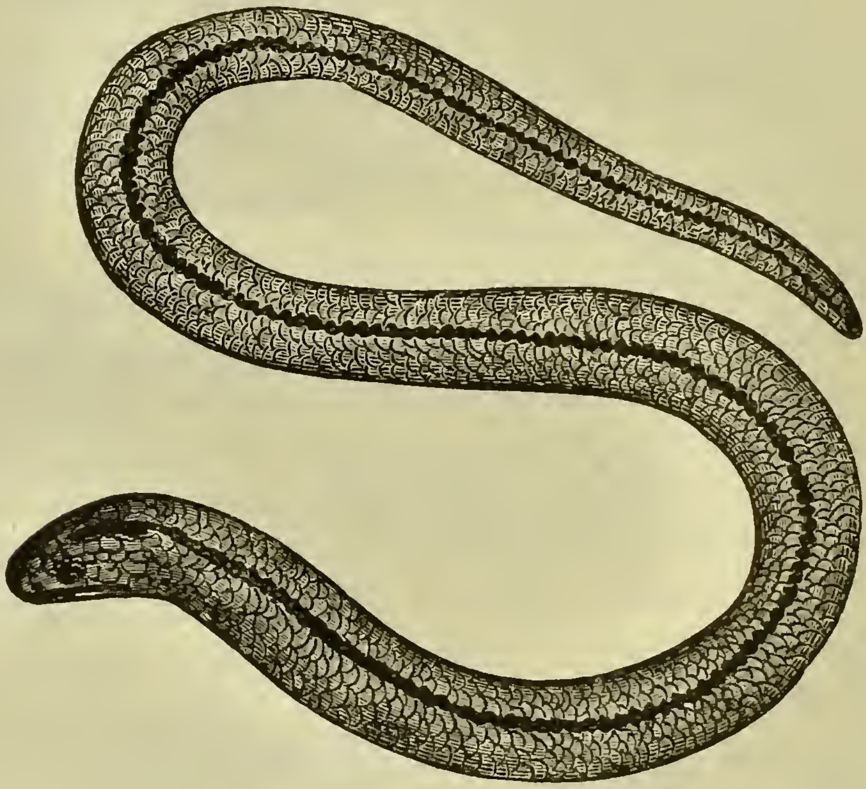


FIG. 205.—BLIND-WORM (*Anguis fragilis*)—after Bell. (Nicholson.)

The true Lizards call for no special comment. Readers are referred to 'Our Reptiles and Batrachians,' by M. C. Cooke. 1893.

CHAPTER XV.

B. SAUROPSIDA—*Continued.*

II.—AVES (BIRDS).

BIRDS are oviparous warm-blooded vertebrates, with a complete double circulation, and are covered with feathers. Their body temperature is about 104° F. The feathers are analogous to the hairs in mammals: they are dermal outgrowths, formed in sacs from small papillæ of dermal origin. A typical feather (fig. 206) consists of the following parts: (1) The "calamus" or "quill" (*C*), by which it is inserted in the dermal papilla; part of the quill is hollow, the basal part being spongy internally. (2) The "rachis" (*R*), which forms the shaft, and which is simply the continuation of the quill: on one side the shaft is grooved, internally it is filled with a soft pithy substance. On each side of the shaft is a so-called "web," the two webs forming (3) the "vexillum" or "vane" (*V*). The vexillum is built up of a number of "barbs" (*B*), the barbs being united by small hook-like "barbules," which attach the barbs together towards the distal part of the feather, but not towards their base. At the junction of the rachis and quill is found a small accessory feather, the "aftershaft" or "hyporachis"; this may be large or simply reduced to a tuft of "down," in which the barbs are disconnected. The feathers vary in structure in different parts of the body. Those of the tail and wings are called "quill-feathers." The longest quill-feathers are in the wing attached to the bones of the hand: these are known as "*primary* feathers" (fig. 207, *A* 1–10). Another series arise from the ulna, the *secondary* feathers (*B*).

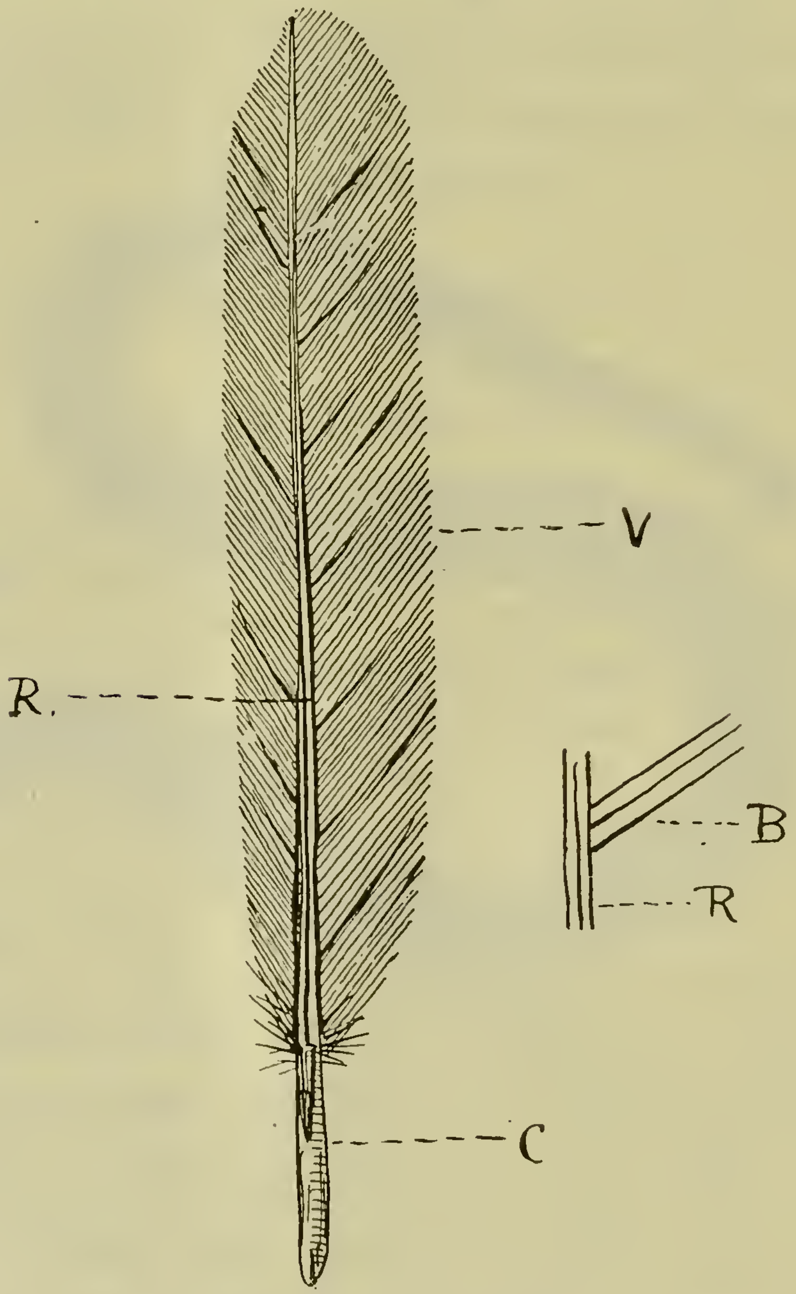


FIG. 206.—FEATHER OF BIRD.

C, calamus; *R*, rachis; *V*, vexillum; *B*, barbs.

There is a small thumb in the bones of the wing; this is also provided with feathers, and is called the "bastard wing" (*BW*). The bases of these large wing-feathers are covered by smaller feathers, the "wing-coverts." The tail-feathers vary in number: they are usually from ten to twelve, but as many as twenty-four are found in some birds. The caudal feathers are called "rectrices," and have no aftershaft; their bases are covered by "tail-coverts." The body feathers cover the mass of "down"; these plumulæ have no hooks to the barbules, so the barbs are quite free. Another form is found in the so-called "filoplumes," which consist of simply a slender shaft with a few barbs at the tip. If we move the feathers of a fowl on one side, we shall observe that they are attached to the skin in definite areas only; the bare intervening spaces are called "apteria," the feather-tracts "pterylæ."

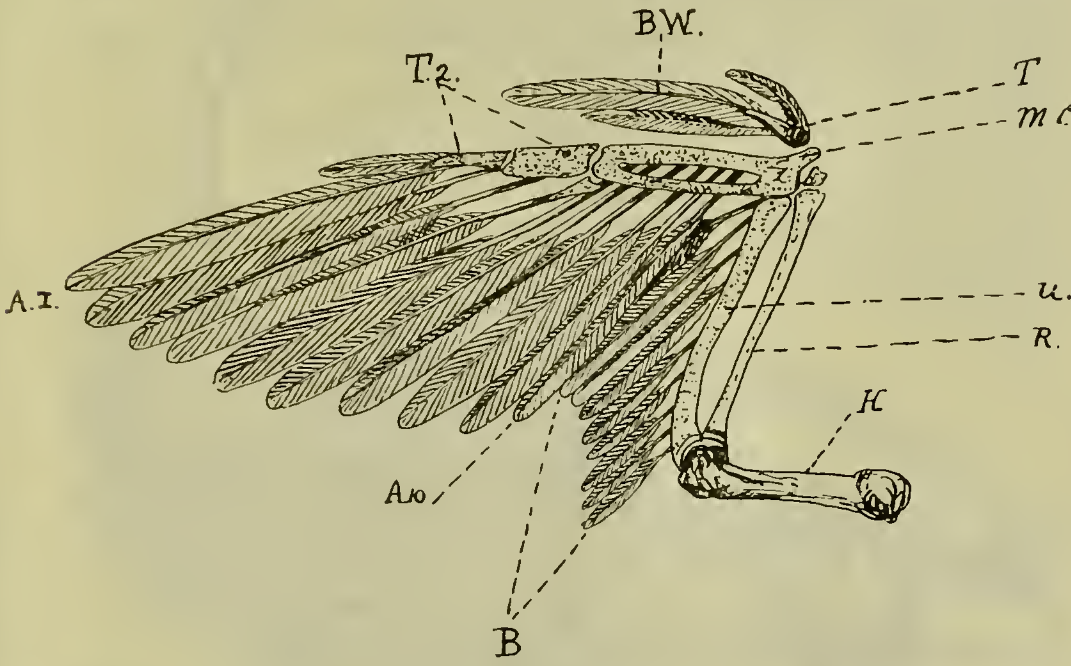


Fig. 207.—Wing of Bird.

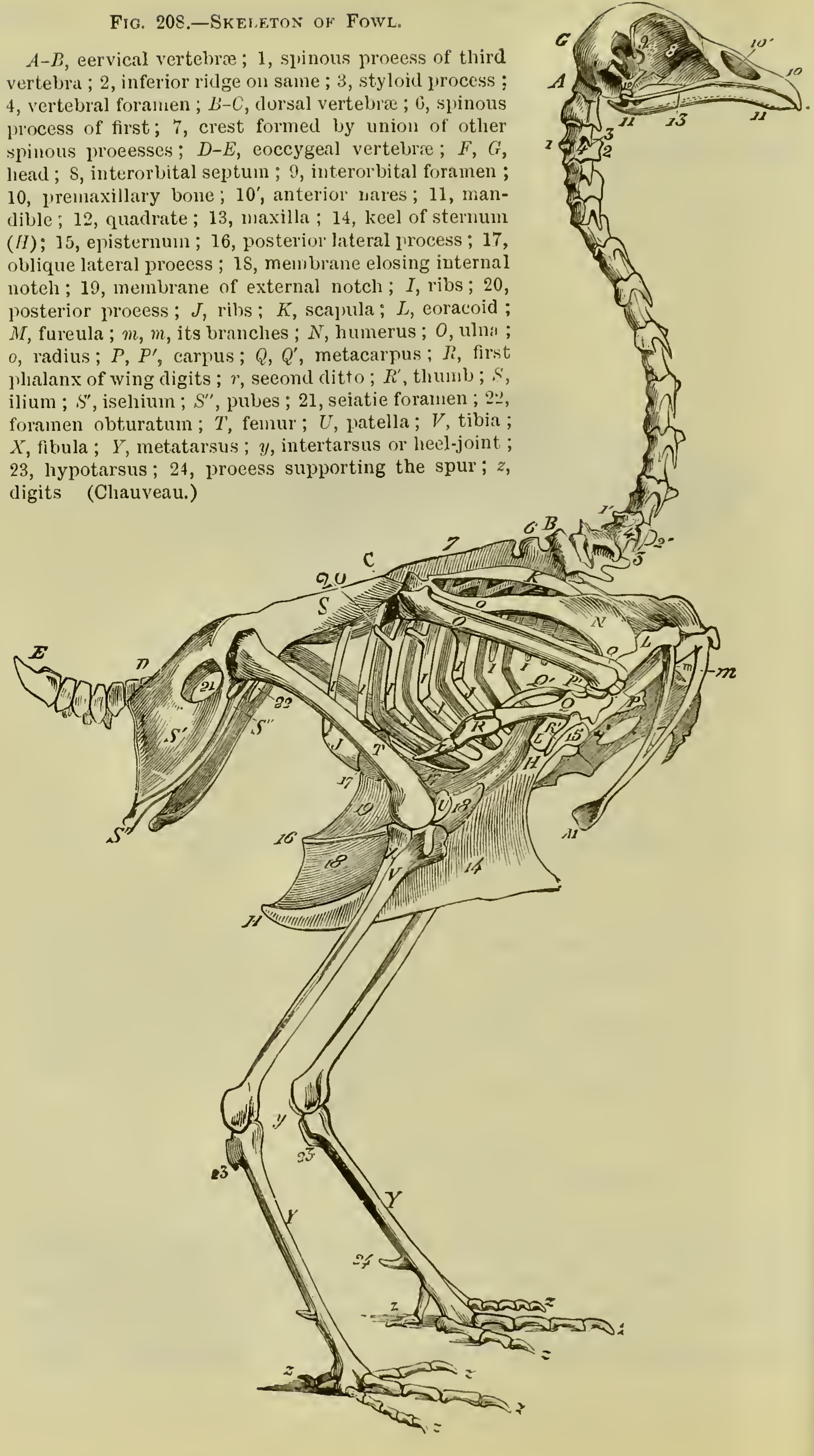
H, humerus; *R*, *U*, radius and ulna; *M.C*, metacarpals; *T*, thumb; *T*.2, two-jointed finger; *B.W*, bastard wing; *A*1-10, primary feathers; *B*, secondaries.

The Skeleton and Anatomy of Birds.

The skeleton of the bird (fig. 208) is remarkable for two things—extreme compactness and lightness. The former is due to the excess of phosphate of lime in the bones, the latter to the presence of hollow spaces in many of the bones. These

FIG. 208.—SKELETON OF FOWL.

A–B, cervical vertebræ; 1, spinous process of third vertebra; 2, inferior ridge on same; 3, styloid process; 4, vertebral foramen; *B–C*, dorsal vertebræ; 6, spinous process of first; 7, crest formed by union of other spinous processes; *D–E*, coccygeal vertebræ; *F*, *G*, head; 8, interorbital septum; 9, interorbital foramen; 10, premaxillary bone; 10′, anterior nares; 11, mandible; 12, quadrate; 13, maxilla; 14, keel of sternum (*H*); 15, episternum; 16, posterior lateral process; 17, oblique lateral process; 18, membrane closing internal notch; 19, membrane of external notch; *I*, ribs; 20, posterior process; *J*, ribs; *K*, scapula; *L*, coracoid; *M*, furcula; *m*, *m*, its branches; *N*, humerus; *O*, ulna; *o*, radius; *P*, *P′*, carpus; *Q*, *Q′*, metacarpus; *R*, first phalanx of wing digits; *r*, second ditto; *R′*, thumb; *S*, ilium; *S′*, ischium; *S″*, pubes; 21, sciatic foramen; 22, foramen obturatum; *T*, femur; *U*, patella; *V*, tibia; *X*, fibula; *Y*, metatarsus; *y*, intertarsus or heel-joint; 23, hypotarsus; 24, process supporting the spur; *z*, digits (Chauveau.)



cavities are more or less connected with the air, and the bones are spoken of as "pneumatic" bones.

The vertebræ of the neck (fig. 208, *A–B*) allow the bird considerable powers of movement in that region; they vary from eight to as many as twenty-three. The dorsal vary from six to ten (*B–C*), the first four being anchylosed together (7), so as to give support to the powerful fore-limbs or wings. We cannot distinguish any lumbars. The bones between the dorsal and the caudal are all united, forming the sacrum much as in mammals; but to this sacrum the ilia (*S*) are joined completely: thus the spine in this region and the pelvis (fig. 212) are incapable of movement. The tail vertebræ (*D–E*) also vary in number, usually eight to ten, and are movable. The last joint of the tail is long and slender, and forms the curious "ploughshare"

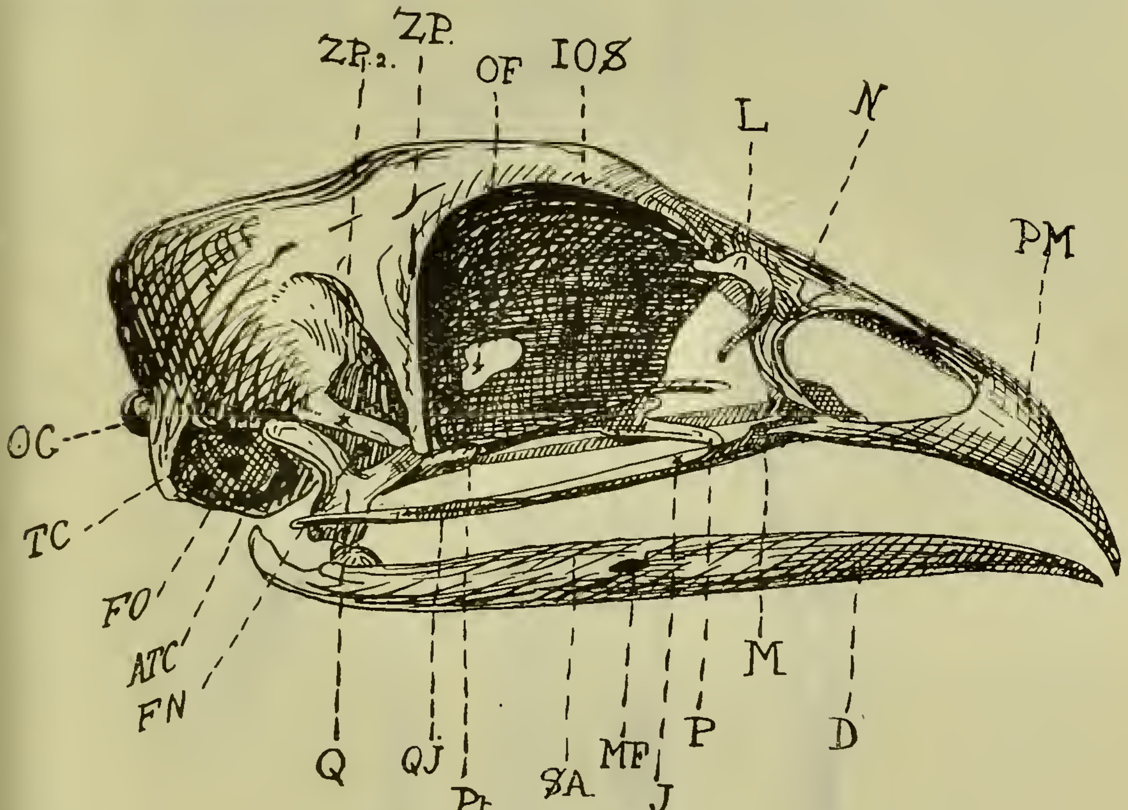


FIG. 209.—SKULL OF FOWL.

PM, Premaxillary; *M*, maxilla; *P*, palatine; *N*, nasal; *L*, lachrymal; *IOS*, interorbital septum; *OF*, interorbital foramen; *ZP*, zygomatic process of frontal; *ZP2*, same of squamosal; *OC*, occipital condyle; *TC*, tympanic recess; *FO*, foramen ovale; *ATC*, anterior tympanic recess; *FN*, foramen of fifth nerve; *Q*, quadrate; *QJ*, quadrato jugal; *Pt*, pterygoid; *SA*, supra-angular; *D*, dentary; *MF*, mandibular foramen.

bone, which is made up of about half-a-dozen caudal vertebræ fused into one piece, and constituting the support for the tail-quills and oil-glands. These latter contain the fluid that the birds preen their feathers with.

The skull (fig. 209) articulates with the vertebral column by a single condyle only. The beak (fig. 208, 10 and 11), so characteristic of the Birds, consists of an inferior and superior mandible, and never in existing species carries teeth. The upper bill (10) consists of greatly elongated intermaxillary bones and small superior maxillary bones on each side. The lower jaw (11) articulates with the skull by the quadrate bone (12), and not direct as in mammals. The thorax is surrounded laterally by the ribs (*I* and *J*), which vary from six to ten pairs: each rib carries a peculiar process called (20) the "uncinate" process,

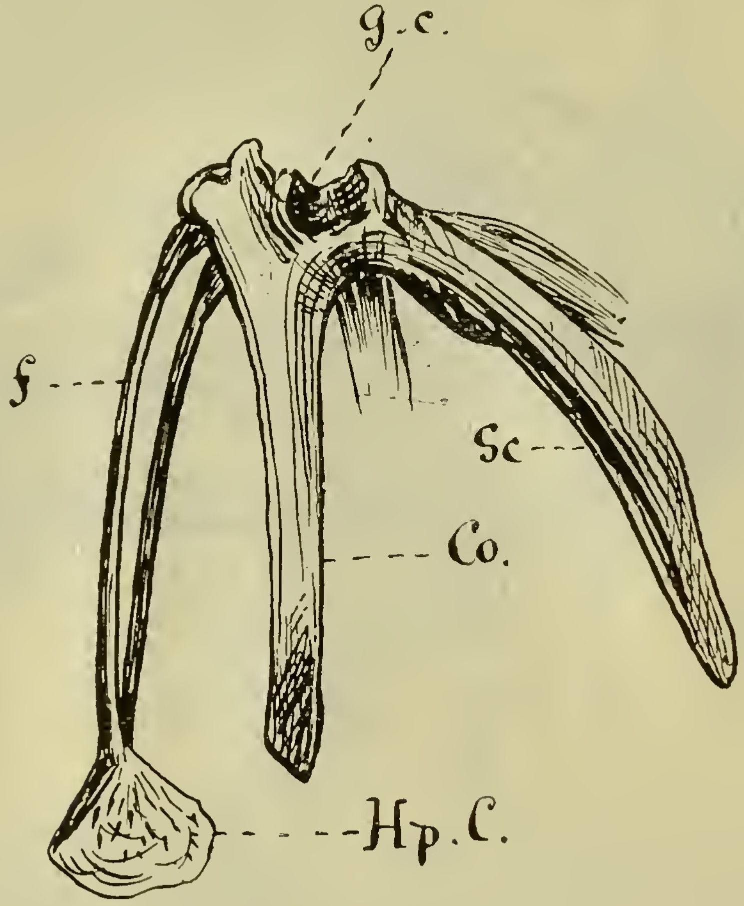


FIG. 210.—PECTORAL ARCH OF FOWL.

g.c, Glenoid cavity; *Sc*, scapula; *Co*, coracoid; *Hp.C*, hypocleidium; *f*, furcula (clavicles).

except the first and last pair. There is a large breast-bone or sternum (14). In flying birds this sternum has a deep sternal ridge or keel, to which are attached the powerful muscles which move the wings. The pectoral arch (fig. 210) consists of a pair of scapulæ (*Sc*), clavicles (*f*), and coracoid bones (*Co*). The scapula is an elongated simple bone; the coracoids are distinct and very strong, and articulate with the upper angle of the sternum; the clavicles form the V-shaped bone popularly called the "merry-thought."

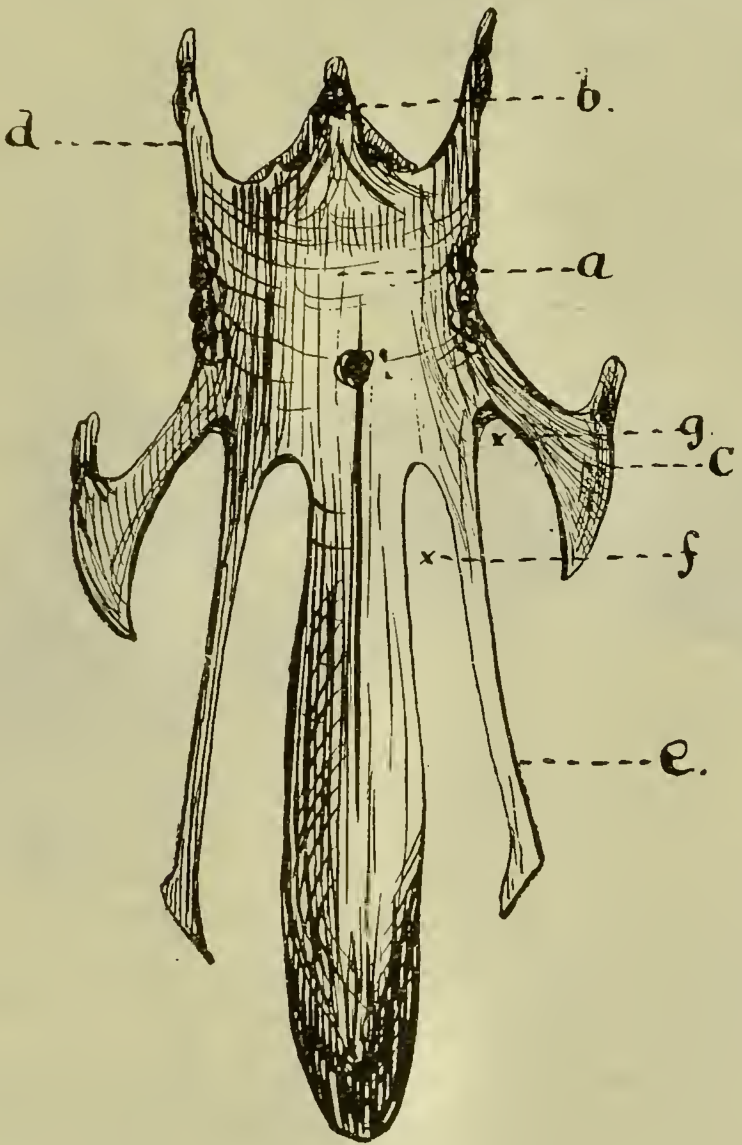


FIG. 211.—STERNUM OF FOWL (front view).

a, Keel; *b*, manubrium; *c*, oblique lateral process; *d*, anterior lateral process; *e*, posterior lateral process; *f*, internal notch; *g*, external notch.

The bones of the fore-limb or wing of the bird are adapted to its peculiar aërial life, and form one of the chief characteristics of the bird's skeleton. This anterior limb consists of a single short and strong humerus (fig. 208, *N*), an ulna and a radius (*O* and *o*) (the former being much the larger bone), two carpal bones (*P* and *P′*), the metacarpus (*Q* and *Q′*), which consists of three bones united together, but free in the middle; at the proximal end of the larger metacarpal is attached the "thumb-bone" (*R′*), which carries the bastard wing. The hind-limb is much as in all animals; but the chief bone is the tibia (*V*), the fibula (*X*) being very rudimentary. The following joint, the metatarsus (*Y*), is characteristic of birds. Four digits are normally present (*z*), three pointing forwards and one behind. There is great variation in the disposition of birds' digits.

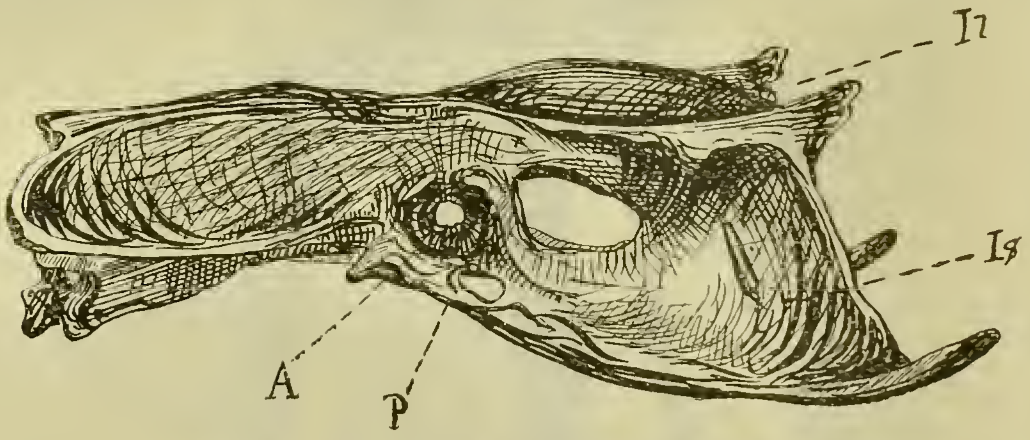


FIG 212.—PELVIS OF FOWL (lateral view).
Il, Ilium; *Is*, ischium; *P*, pubes; *A*, acetabulum.

The Digestive System.—As already said, the bill of birds never contains teeth: it is variable in appearance, and is used for eating the prey and food generally, for prehension, and in some as an organ of touch. The base of the upper bill is often surrounded by a circle of skin devoid of feathers, the "cere." The tongue is mostly hard and horny, and is supported by the hyoid bone. The digestive tract consists of a long gullet or œsophagus (fig. 213, *Oe*), which has a sac-like dilatation in front of the "merry-thought," the *crop* (*C*). This crop is seen in carnivorous and graminivorous birds. Here the food is retained prior to the gastric digestion. The œsophagus is followed by the *proventriculus,* which is the true stomach in which gastric digestion takes place. This first stomach corresponds with the cardiac end of the mammal's stomach. The pyloric end is represented by the "gizzard" (*G*), a large extremely muscular cavity situated below the liver. There are two distinct types of this grinding stomach: in raptorial birds it consists of a simple membranous sac, but in graminivorous birds, which eat hard and not easily digested food, the gizzard consists of a thick muscular cavity which is lined by a hard epithelium. By the muscular action of the walls of the gizzard the food is ground up against the horny walls. In all birds we find in this second stomach small stones, cinders, and grit. These aid in the trituration of the food. They are essential to the health of the bird, hence poultry are given "grit" to eat. This grit should be natural, not sharp needle-like pieces of flint, such as some poultry merchants advertise, which only damage the walls of the gizzard and do not grind the food. Many inflammatory diseases of the gizzard I have traced to this reprehensible practice. The intestine consists of two parts, the small and large intestine, and ends in the cavity called the *cloaca* (*CL*). The large intestine commences where the two long blind tubes originate, the "cæcal tubes"

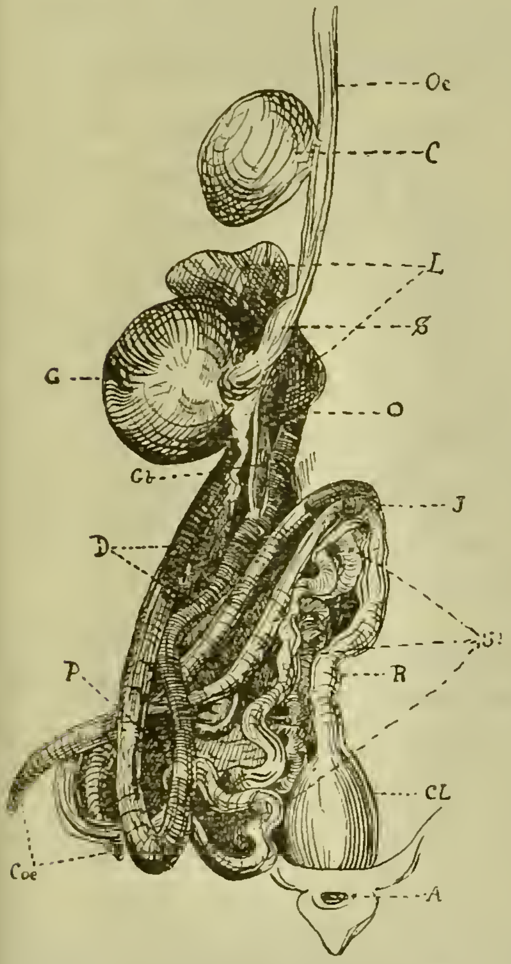


FIG. 213.—ALIMENTARY CANAL OF FOWL.

Oe, Œsophagus; *C*, crop; *S*, proventriculus; *G*, gizzard; *D*, duodenum; *Si*, small intestine; *Cæ*, cæca; *J*, junction of cæca; *R*, rectum; *CL*, cloaca; *A*, anus; *L*, liver; *Gb*, gall bladder; *O*, right lobe of liver; *P*, pancreas.

(*Cae*), which are generally present in birds. The cloaca is the cavity which receives the rectum, ureters, and sexual ducts, there being no distinct sexual openings in the class Aves. Salivary glands open into the mouth, the liver (*L*), and pancreas (*P*) into the small intestine near the gizzard.

Respiratory organs in birds not only consist of lungs, but also of "air-sacs" and spaces in the bones. The lungs differ from those of mammals by not being freely suspended in the pleural cavity: they are two in number, spongy, and bright red in colour. The air-sacs are prolongations of the lining membrane of the bronchi, which spring from the bronchial tubes just before they enter the lung. These air-receptacles penetrate the thorax and abdominal cavity. They become filled with air prior to the bird taking flight, and thus reduce its specific gravity, at the same time bringing air in direct contact with the blood in other parts of the body besides the lungs. The air-sacs are continued in adult birds into the bones. In young birds the pneumatic bones do not exist to the same extent.

The *heart* in birds consists of four chambers, two auricles and two ventricles. The heart essentially agrees with that of mammals, as does the general circulation of the blood, so no further reference need be made to this subject.

There is no urinary bladder in birds: the kidneys are two in number and elongated; their ducts open into the cloaca. In regard to the *reproductive organs*, the chief characteristic in birds is that there is only one functional ovary (fig. 214) and Fallopian tube in the female; this single ovary is that of the left side. I have sometimes in the fowl found the right ovary more or less developed. The oviduct is a long tortuous tube in which the ovum receives first the "white" or albuminous covering of the yolk. Towards the end of the egg-tube dilatations appear: in these the eggs receive the shell, which consists of carbonate of lime. A deficiency of this in the bird's system results in so-called "soft eggs." The egg is then passed into the cloaca, and so out of the vent. The eggs of birds are hatched by incubation. The young are provided with a curious calcareous knob on the upper mandible, by means of which they crack a hole in the egg-shell when ready to escape. Some can feed as soon as they have escaped from the egg-shell—precocious young; others have to be fed by the parents—nestlings.

Birds are found in all climates, and may be residents, migrants, or gipsy-migrants.

In cold and temperate climates many birds do not remain all the year; these are called "migrants." Migrants pass at the approach of winter to a warmer climate, and return again to nest in the spring. Prior to migrating the birds usually collect in flocks. These migrations generally take place about the same date every year. Most migrants are insectivorous, and even if the temperature were warm enough for them, they could not subsist upon our scanty winter fauna.

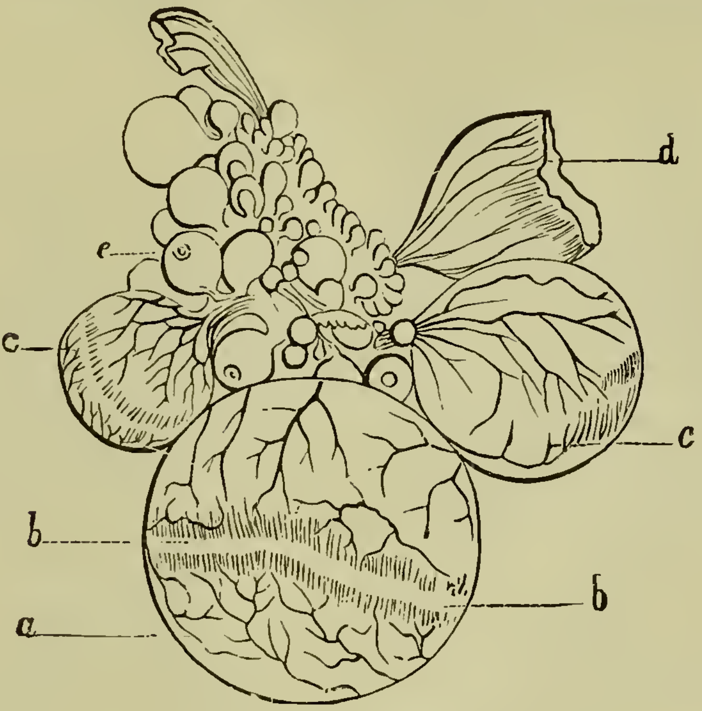


Fig. 214.—Ovary of Bird.

a, *c*, *c*, Ova in various stages of development; *b*, streak without vessels indicating the point where the vesicle is about to rupture to allow ova to escape; *d*, ruptured vesicle; *e*, very small ovum showing cicatricula. (Chauveau.)

There are other birds which move from place to place in an erratic manner, the so-called "gipsy-migrants," which leave one district for another owing to scarcity of food, but have no fixed place of migration. This form of movement we see in Tits (*Paridæ*) and Woodpeckers (*Picidæ*).

Those birds, such as the blackbird and thrush, which are with us throughout winter and summer, are called "residents."

Fossil birds present many peculiarities. Some (*Odontornithes*) have teeth; others of older date have distinct lizard-like characters, such as the feather-tailed *Archeopteryx*.

CHAPTER XVI.

BRITISH BIRDS.

Most birds are of some economic importance to the farmer and gardener. Many are extremely useful in keeping down an excess of insect life and other vermin more or less destructive to our crops. There are also some birds which are obnoxious by destroying the buds of fruit-trees, by eating grain, and by their depredations amongst poultry and game-birds. The most important species only will be mentioned here, space forbidding a more detailed description.

The old classification of Birds into Natatores, Grallatores, Rasores, Scansores, Passeres, and Raptores is not followed here, as by it birds of a totally different structure are grouped together: for instance, the Ducks and Geese, formerly united with the Gulls, are quite distinct in structure, and cannot be reasonably grouped with them. There is no doubt but that the so-called Passerine birds are the most highly developed, while Grebes and Divers are some of the lowest. We therefore commence with the latter, as we are here tracing life from the most simple forms, the Protozoa, to the most highly developed animals, the Mammalia. The groups are taken in the order given by Dr Hans Gadow.[1]

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[1] A Classification of Vertebrata, Recent and Extinct. Gadow. 1898.

1. Colymbiformes.

GREBES AND DIVERS.

The Grebes and Divers call for little comment here: they are included in the two families *Podicipedidæ* and *Colymbidæ* respectively. Of these we need only deal with the first mentioned.

The *Grebes* (*Podicipedidæ*) are characterised by their short wings, with the first three primary feathers nearly equal and the longest in the wing, by the absence of any tail, by the elongated conical form of the bill, and by the structure of the foot, which is known as a "split-swimming foot" (fig. 215). This form of foot as seen in the Grebes has three toes in front and one behind, the three front toes much flattened, united together at the base, and edged with lobate webbing; the hind toe is also flattened, while the claws are large and flat. The best-known British species is—

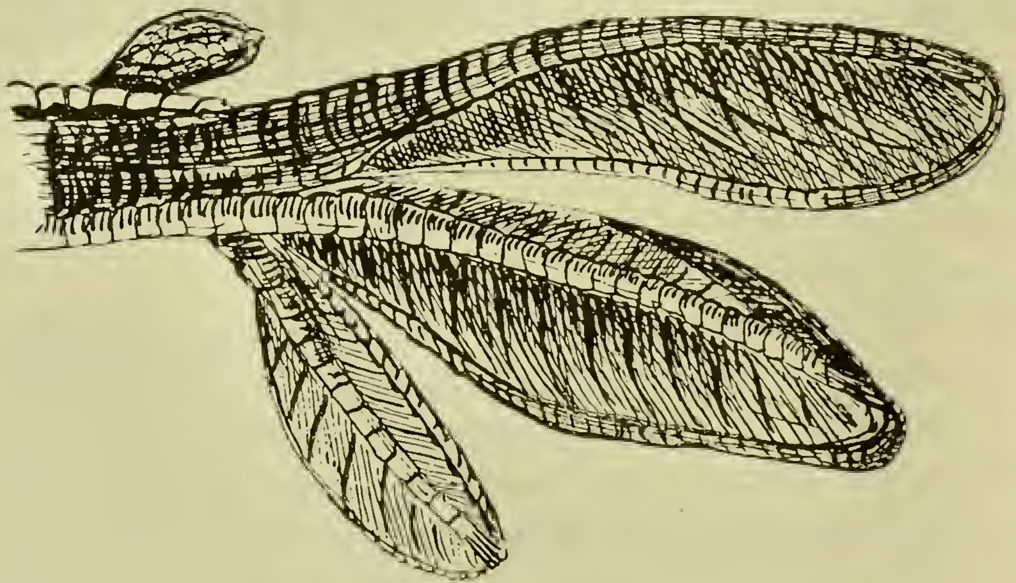

FIG. 215.—SPLIT-SWIMMING FOOT OF GREBE (*Podiceps fluviatilis*).

The *Dabchick* or *Little Grebe* (*Podiceps fluviatilis*).—The little grebe is widely distributed over England, and may be seen all the year round along streams and rivers, upon lakes and pools, especially revelling in those of a reedy nature. In colour the dabchick in summer is dark-brown above and greyish-white below; cheeks, throat, and sides of the neck tawny; bill dusky-brown, greenish-yellow at the gape; legs and toes dull greenish-brown. In winter the plumage is paler, and the chin is white instead of black. In length the little grebe varies from nine to ten inches. They form their nest as a floating structure attached to water-plants; it is usually composed of reeds, and is often of a large size. Nesting is said to last from April to August. Six white eggs are generally laid, and are covered up by the bird when the nest is left. The young grebes are quite light in colour, and, like all members of this family, are carried about by the parents on their back, sitting close between the bases of the wings. All the grebes seem to have a habit of swallowing feathers and of ejecting them again with other undigested products, like the owls. The food consists of small fish, insects, and various small aquatic animals, as well as vegetation.

4. Ciconiiformes.

HERONS, BITTERNS, &c. (ARDEÆ).

These birds have all long legs and long strong-pointed bills. The three chief groups are the Herons (*Ardea*) and the Bitterns (*Botaurus*), forming the family Ardeidæ, and the Storks (*Ciconia*), forming the family Ciconiidæ.

The *Herons* (*Ardea*) have long straight bills in the form of a long compressed cone. The legs long and slender, and naked above the tarsal joint; three toes in front, the outer one joined to the middle one by a membrane, one toe directed backwards; claws long and very sharp. They have on their breasts and flanks tufts of decomposed powdery feathers for powdering the plumage. Our best-known example is the Common Heron

(*Ardea cinerea*), which nests in companies, "heron-shaws," upon the tops of trees, on old walls amongst ivy, &c. They may commence to build their large nests in January if the weather is mild; but February is the general time for them to repair to their nesting-places, which they frequent year after year. The nests are large flat structures, formed of crossed sticks and lined with grasses, &c. They lay three or four bluish-green eggs about two and a half inches long, which hatch out in twenty-eight to twenty-nine days. Young herons are nestlings, and remain with the old ones about the heron-shaws until August. In Richmond Park they continue all the year round in their nesting-wood. The adult male heron is three feet long, and has a deep blue crest, the upper parts being slaty-grey, the under parts dull greyish-white; sides of the head and neck white, bluish-brown streaks run down the neck. The female is not so bright in colour as the male. The bill is yellow. Herons feed on a great variety of food, and do some good by destroying water-rats and field-mice; they also eat quantities of insects, molluscs, and frogs. Fish also are greedily devoured by them, especially coarse fish, more especially eels. They fly with their legs stretched straight out behind, and move their wings very slowly, and so can easily be recognised when flying. Several other species occur in England occasionally.

The Bittern (*Botaurus stellaris*) was a resident bird, but is now very rare, chiefly occurring as a winter visitor. The Storks (*Ciconia*) are most useful as locust destroyers.

5. Falconiformes.

VULTURES, HAWKS, EAGLES, BUZZARDS, &c. (ACCIPITRES).

There are two families of the Accipitres in Great Britain—namely, the *Vulturidæ* and *Falconidæ*. The first-named, the Vultures, are so extremely rare (only a few stragglers having been recorded) that they call for no further comment.

The *Falconidæ* include all our Diurnal Birds of Prey—the Hawks, Falcons, Buzzards, Kites, Harriers, and Eagles. They have a hooked beak furnished with a sharp projection on each side; the cere is always devoid of feathers, with the rounded nostrils placed laterally upon it. The feet are raptorial—that is, are armed with long, sharp, curved talons (fig. 216). Unlike the Vultures, they have fourteen cervical vertebræ. All the Accipitres have the oil-gland tufted. They eject the undigested parts of the food from ten to twenty hours after ingestion as small rounded or elongated pellets. Vision is extremely keen, and most are endowed with very strong powers of flight. The female is always larger than the male. Many of these Raptores are decidedly beneficial, whilst others are just as harmful; the indiscriminate slaughter of them has been attended with disastrous results, by the undue increase of many of their kinds of prey. The most important economic species are the following:—

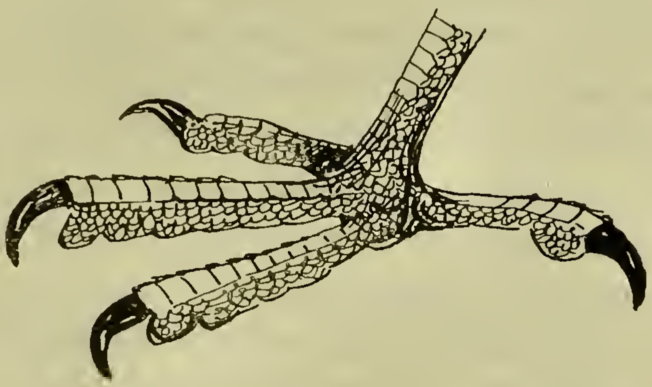

Fig. 216.—Foot of Raptorial Bird.

Belonging to the genus *Falco*, which have short bills curved from the base, with a strong, projecting, cutting tooth on the edge of each upper mandible; with long pointed wings, and long, curved, sharp claws, are first—

The *Kestrel* or *Wind-hover* (*Falco tinnunculus*).—This is one of our most abundant and useful birds of prey. It is generally present over Great Britain, occurring in greater numbers in winter than summer, due to immigrants from the Continent. The adult male kestrel has a bluish-grey head, neck, and tail; the tail has a broad black band towards the end, and is tipped with white; the back is pale reddish-brown towards the head, greyish-blue near the tail, with small dark spots in the male; the female has the back rufous and with more black bars, and there are also several narrower bands of dark-brown on the tail; the legs and cere are yellow. The male varies from twelve to fourteen inches, the female usually one or two inches longer. The kestrel nests in a variety of places: very often the nests of rooks and wood-pigeons are taken possession of by them; others lay their eggs in hollow trees, in holes, in quarries, and cliffs. From four to six eggs are laid, very variable in appearance, some being creamy-white with a few reddish-brown spots, others almost entirely reddish-brown. The kestrel is often looked upon by gamekeepers and others as a destructive bird, and ruthlessly destroyed. Instead of doing harm the windhover does a great deal of good, for its food consists mainly of field-mice, voles, and insects, especially grasshoppers, locusts, and beetles. Very seldom are birds touched by *F. tinnunculus*. It should therefore be strenuously protected.

The *Merlin* (*F. æsalon*) and the *Hobby* (*F. subbuteo*) are both similarly destroyed, yet they do little harm, if any. The former feeds on small birds, such as larks, pipits, and thrushes; the latter is chiefly an insect-feeder, cockchafers and dragon-flies being its choicest food, although, like the merlin, small birds, especially swallows and martins, may be taken by it.

The *Peregrine Falcon* (*F. peregrinus*).—This is one of the finest falcons, and the one most sought after for "hawking." The adult peregrine reaches nineteen inches in length in the female, some three or four inches smaller in the male. The head and cheeks are black, the back being slaty-grey with black bars; the under parts rufous, barred with black, and the cere and legs yellow. This falcon lays its eggs in nests of the crow, raven, &c., on cliff edges and in hollows scraped out in similar places, as well as on high buildings and monuments. The eggs are laid in April, and vary from two to four in number, nearly two inches long, and often brick-red in colour, many being only freckled with the red. The young falcons are always driven away by the parent towards the end of the summer, one pair keeping off fresh arrivals for some distance round their "eyrie." Peregrines are undoubtedly injurious to game. Their chief food consists of grouse, partridges, ducks, pigeons, kestrels, and various other birds, and perhaps where this falcon is *abundant* there is some excuse for destroying it.

The *Sparrow-hawk* (*Accipiter nisus*).—The sparrow-hawk belongs to another genus, *Accipiter*. This genus is characterised by the bill bending from the base, and by the cutting margin of the upper mandible having a distinct festoon; the wings are short and the legs long and slender, the claws being curved and very sharp, the middle toe long and slender. The sparrow-hawk is a very common bird throughout Great Britain in wooded districts. The male is slaty-blue above, buff below, barred with tawny-brown; the tail is brown with three to five dark bars; the cere is greenish-yellow, and the legs yellow. The female has a greyish breast barred with brown, and is much larger than the male, being some fifteen inches long. The sparrow-hawk builds a nest of her own, although she sometimes uses as a foundation the remains of a crow or rook nest. As many as six eggs may be laid in May at intervals of two days. The sparrow-hawk, unlike the kestrel, is a great nuisance, for its chief food is game and young poultry, amongst which it is especially destructive when it has a brood of young. The meal is eaten on the ground, the sparrow-hawk requiring both feet to secure its prey. They hunt along hedgerows and wood-sides, and devour also large numbers of small birds.

The *White-tailed Eagle* (*Haliaëtus albicilla*).—Of the two eagles found in Great Britain the white-tailed or sea-eagle is that most often met with. It is this species that is recorded as the Golden Eagle (*Aquila chrysaëtus*) every now and then in the southern counties. The two species are readily distinguishable by the structure of the legs and feet. The sea-eagle has the leg above the foot devoid of feathers, and the toes with a single row of scales all the way down; the golden eagle has the leg feathered down to the toes, and the upper part of the toes not scaly but reticulate, three scales only being present towards the tip. A female white-tailed eagle will reach thirty-four to thirty-six inches in length. They breed in Scotland in April, but not now in England. It is this species only that we find in the South. The food consists of carrion—birds, animals, and fish. The golden eagle takes lambs, and even fawns, whilst hares and grouse form its staple food. They no doubt at one time in the North were destructive to sheep; but they are now far too scarce to do any harm, although the golden eagle is if anything on the increase in Scotland, owing to its being now more or less preserved by landowners.

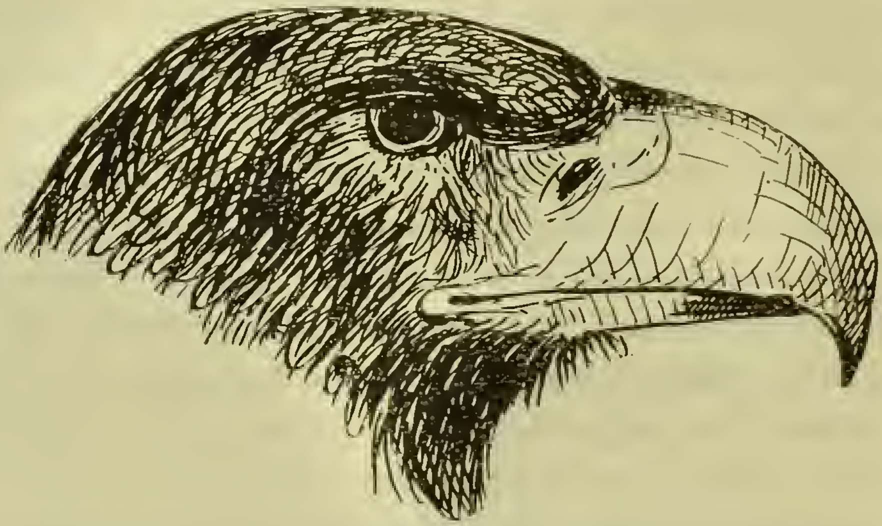

Fig. 217.—Head of White-tailed Eagle (*Haliaëtus albicilla*).

The two British Buzzards (*Buteo vulgaris* and *B. lagopus*) are great destroyers of mice and voles, frogs and snakes. They are sometimes said to destroy partridges and grouse, but this is very rarely the case.

Amongst the Harriers (*Circus*), the Marsh-harrier is said to destroy poultry; but if it does, it is only to a limited extent, for their chief food consists of small mammals, small birds, frogs, and snakes—in fact, the above form the usual diet of all the Circi.

It will thus be seen that, with the exception of the sparrow-hawk and peregrine, the Accipitres are not destructive to any great extent; but, on the other hand, many are decidedly beneficial as destroyers of the hosts of voles, mice, and other small mammals, which often increase with alarming rapidity where these rapacious birds have been persistently persecuted. Poultry suffer from the sparrow-hawk, and sometimes the merlin and hobby; but the few chicks the two latter take are soon made up for by the good done by their destroying vermin.

6. Anseriformes.

Ducks, Geese, and Swans (Anseres).

The Ducks, Geese, and Swans are included in the family *Anatidæ*, which contains as many as seventeen genera in Great Britain. The Anseres are characterised by the beak (fig. 218) being more or less flattened and covered with a fine tactile skin; the edges of the bill are furnished with a series of lamellæ (*L*), forming a kind of fringe, which acts as a strainer to the mud in which they seek their food. The bill is most sensitive, being abundantly supplied with branches from the fifth cranial nerve. The legs are provided with a three-toed swimmer, the fourth toe pointing backwards, and is free (fig. 219, B). The body of the Anseres is heavy, and densely covered with down beneath the contour feathers, yet these birds are capable of great powers of flight. The males

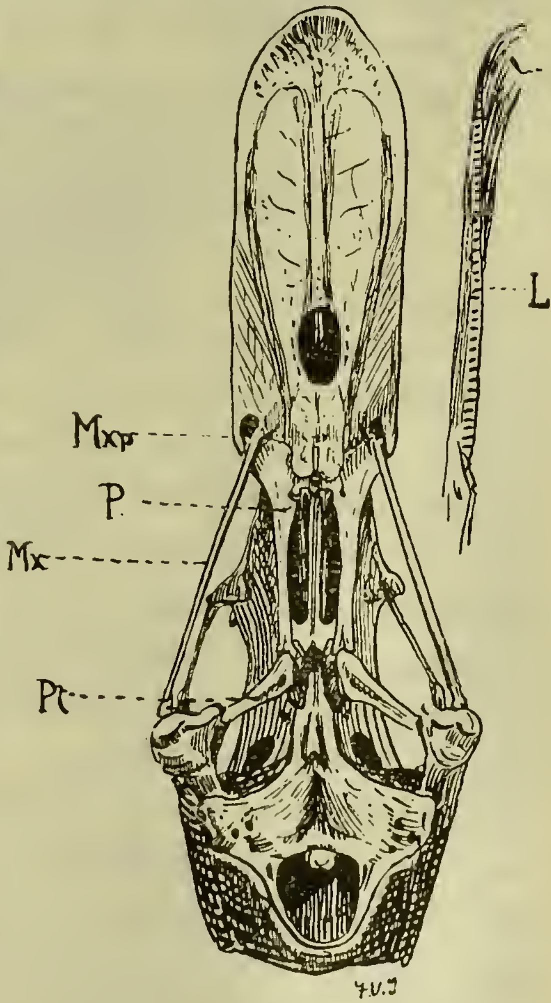

Fig. 218.—Skull of Duck.

especially have a peculiar harsh note, which is perhaps accounted for by the large and peculiar enlarged end of the trachea. They are mostly found in shallow fresh waters, where they hunt about in the mud, but are also partly marine in habits. The young are always precocious. Wild Ducks, Geese, and Swans are strictly monogamous. We need here only consider the true Ducks, Geese, and Swans.

Amongst the Geese we find the following important genera :—

1. *Anser*, in which the bill is nearly as long as the head; elevated and covered with skin at the base, the under mandible always being smaller than the upper. The nostrils are placed about the middle of the beak, and are pierced anteriorly, lateral in position (fig. 219, A). Legs under the middle of the body.

2. *Bernicla*, in which the bill is much shorter than the head, edges nearly parallel, the lamellæ being unseen.

GEESE (ANSER AND BERNICLA).

Geese are often plentiful in Great Britain. They appear in flocks especially during the winter, when they have migrated southwards. At least eight species have been recorded in our islands. Of these the Grey Lag Goose (*Anser ferus*), the Bean Goose (*A. segetum*), and the Brent Goose (*Bernicla brenta*) are the most frequently seen inland, where they sometimes do slight damage to various crops. The geese fly in two forms, either in a V-shape or in a long wavy or slanting line. They especially move on the wing at dusk and are gregarious. Most of the year is spent in high latitudes.

The *Grey Lag Goose* (*A. ferus*).—At one time this goose was very abundant in England, now it is much scarcer; yet I have seen flocks in the eastern fen districts carrying destruction along with them. The bill is flesh-colour, with a white nail; the upper plumage ashy-brown, the feathers here and there bordered with dusky-white; the under-plumage is ashy-grey barred with brown on the sides and beneath, pure white behind. The rump and wing-coverts are bluish-grey. The legs are dull pink. Length often nearly three feet. These geese arrive in the autumn, and at once repair to the fields and marshes, where, moving about in flocks, they trample down the young corn, attack the turnips, and often do endless damage. The "grey lag" is found all over Europe, in Northern Africa, and to the east as far as Persia. There seems little doubt but that this species has given rise to some of our domestic geese. It is uncommon in the south of England and on the west coast. The "grey lag" still breeds in Scotland, but in decreasing numbers. In the latter place they incubate in April, when the ganders leave the geese and collect together on pieces of water.

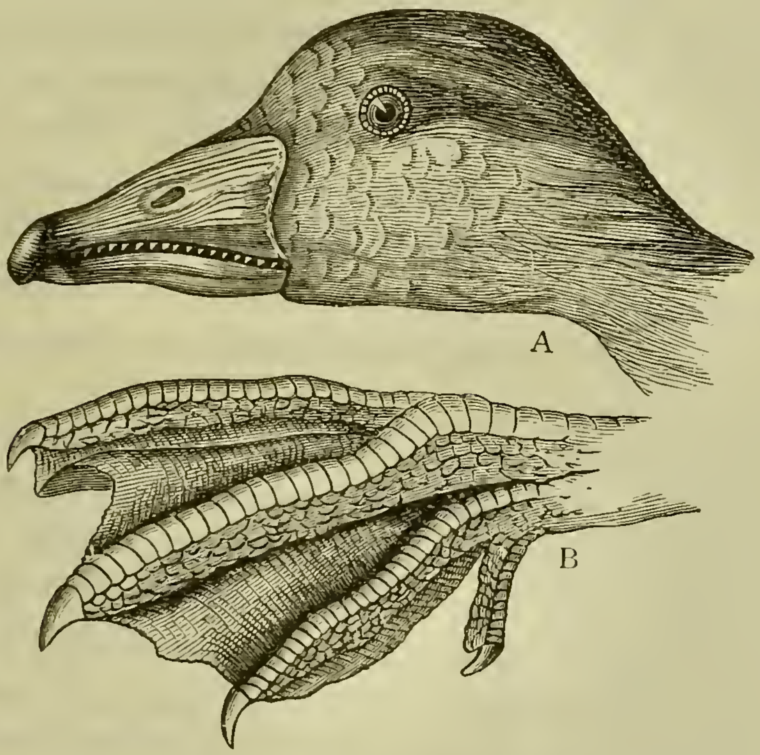

FIG. 219.—A, HEAD OF GREY LAG GOOSE; B, FOOT OF DOMESTIC GOOSE. (Nicholson.)

The *Bean Goose* (*A. segetum*) is another common species. The wings when folded are much longer than the body; the base of the orange bill is black and so is the nail; the upper plumage is ashy-grey, the under parts dusky and pure white, and the legs orange. This goose also appears in large flocks. It may be seen from October to April, especially during the period of its migration. Like the former, it feeds on grass, roots, corn, and other vegetation, pulling up and trampling down far more than is devoured. The bean goose is, as its name implies, especially fond of pulse; newly sown beans in spring often suffer from its ravages. It breeds nowhere in England. In Cornwall it is often very abundant, and perhaps in most districts except the east coast it is one of the commonest geese.

The *Pink-footed Goose* (*A. brachyrhynchus*) is also very abundant in parts of England during the winter months, especially in the eastern counties, but in the south we seldom see it. It is smaller than the bean goose. Like the bean goose, it has a black nail and very similar beak; but the white markings of the tail are much broader, and the wing-shoulder is bluish-grey in colour.

The *White-fronted Goose* (*A. albifrons*) is also abundant in severe weather in the south and south-east of England. It is smaller than the grey lag, but, like it, has a white nail at the tip of the bill. The base of the mandibles and forehead are white; the back is brownish-grey; breast and belly white, with broad bands of black. Bill, legs, and toes orange. The female is paler, and has much less black on the breast. It is found in Syria, Egypt, &c., and with the grey lag has shared in the origin of our domestic varieties.

The *Brent Goose* (*Bernicla brenta*) is the most abundant of all British geese. It is found about the south and south-east coasts all the winter, but seldom comes inland, feeding on the mud-flats upon crustacea, weeds, &c.

Domestic Geese and their Origin.—The various varieties of Geese are no doubt descended from the widely distributed grey lag, which once bred in abundance in our country. The grey lag has been known to cross readily with tame geese in preference to any others. The white varieties are easily accounted for by variation under domestication, and judicious selection and breeding. The grey lag is very widely distributed, being found in abundance in India. The white-fronted goose may also have been in some way connected with our present stock; but that the grey lag is the chief originator of the Toulouse, Embden, and other geese there is very little doubt. Geese under domestication commence to lay in February and March, and may deposit as many as eighteen eggs, but that is above their average. The young goslings appear about the twenty-ninth to thirtieth day after incubation commences. Although wild geese sometimes do harm in this country, they cannot be said to be of much importance to the agriculturist; but domestic geese are thus important, not only on account of their value, but for the good they can do in exterminating grubs and vermin in the soil in orchards, &c.

SWANS (CYGNUS).

Swans have a long slender neck, with sixteen cervical vertebræ. The bill is higher than wide at the base and depressed at the tip, and both mandibles are furnished with serrated lamellæ along their sides. The male and female cygnus are alike in plumage. The commonest swan in England is the Mute Swan (*C. olor*), which is said to have been introduced from Cyprus by Richard I. It is now found abundantly not only semi-domesticated but wild. The Swans pair for life, and breed on islands, amongst reeds, &c., in May. The nests are large structures built of reeds and rushes. Four eggs are laid by young females, who commence to breed in their second year as a rule; older females may lay as many as ten eggs, of a dull greenish-white colour, nearly four inches long. The period of incubation is between thirty-six and forty days, the young "cygnets" being looked after by the parents for some time, generally until next breeding season. The cygnets are sooty-grey, with a dull grey-coloured bill. The food of Swans consists of water-plants, aquatic insects, and grain.

DUCKS (ANATINÆ).

The Ducks, of which there are a great number of genera, are sometimes provided with a very narrow membranous lobe to the fourth toe. The legs are short, and placed behind the middle of the body; the bill is about the same width all along, or may be broadened at the tip. The nostrils are small and near the base in the true Ducks (*Anas*), and large in the Sheldrakes (*Tadorna*). The period of incubation in ducks is about a month, always longer than in the fowl.

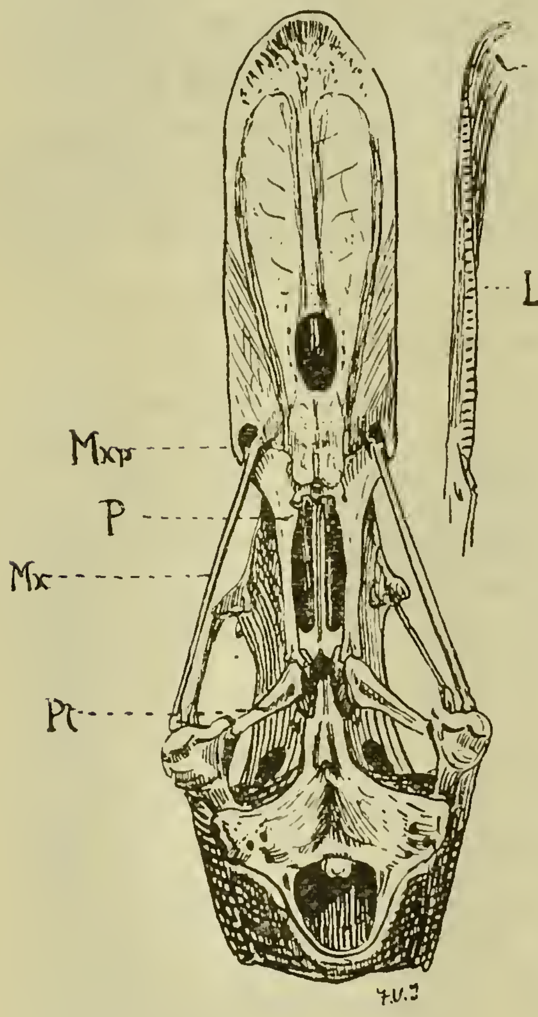

FIG. 220.—SKULL OF DUCK (Desmognathous).
Bpt, Basi-pterygoid; *L*, lamellæ of bill.

Here are included the Common Sheldrake (*Tadorna Bellonii*), one of our largest and handsomest ducks; the Teal (*Anas crecca*); the Widgeon (*A. penelope*); the Wild Duck (*A. boschas*), &c. The last only needs claim our attention.

The *Wild Duck* (*Anas boschas*). — The mallard or wild duck is found generally throughout Great Britain, and breeds wherever there are swamps and water. The term "mallard" is properly applied to the "drake" only, "wild duck" to both sexes. The winter plumage of the drake is, as every one must have noticed, very different from the duck. This winter plumage is seen from October to May; but in the summer, when both sexes moult, the drake assumes the plumage of the duck. The young ducklings also appear in the same garb in both sexes. One notices a similar change in many domestic ducks, especially Rouens and others that assimilate to the wild ducks or their ancestral plumage. *Anas boschas* is found all over the Northern Hemisphere. In England it remains throughout the year; but in winter its numbers increase, owing to large enforcements coming from the North as the cold approaches. The nests are built in all manner of places—on the ground, amongst reeds, grass, and on the top of trees. The young can feed at once, but are unable to fly until nine or ten weeks old. The ducklings feed upon tadpoles, water-insects, and small grubs. The old birds feed upon a variety of substances—water-plants, land-plants, oats, and grain generally, fish and fish-spawn. It is said that they sometimes do some harm in corn-fields, but the damage must be comparatively slight. In very cold weather they are found along the coast. The wild duck commences to lay about March in the south of England, later as we proceed northwards. The nest is on the ground generally, and is made of grass lined with down; in it are laid twelve greenish-grey eggs. The mallard is monogamous in its wild state, but under domestication our varieties which have sprung from it are polygamous.

The *origin of our domestic breeds* is no doubt correctly traced back to the *Anas boschas.* Darwin says that, "with respect to the origin of the domestic duck, I have considered the case well, and am convinced that all breeds, including the black Labrador and penguin ducks, are the descendants of the common wild duck." The Rouen duck very nearly resembles the wild species, only it is larger in form, and I have found that with "in-and-in breeding" they soon become almost identical with the wild species.

8. Galliformes.

The RASORES (GALLINÆ) or "SCRATCHING BIRDS" are often spoken of as gallinaceous birds. They are of considerable interest to us, as they contain most of our domesticated birds, such as the Fowls, Turkeys, Guinea-fowls, and Pea-hens. Our game-birds also belong to the Rasores—the Partridges, Pheasant, Grouse, and Blackcock. These have all a convex-vaulted upper beak, with the nostrils pierced in a membrane close to the base of the beak, and covered by a cartilaginous scale. The legs are strong in the most typical forms, and always with feathers down to the tibio-metatarsal joint. The four toes, of which three are directed forward and one behind, are all armed with thick claws for scratching (fig. 221). The males differ, as a rule, very much in plumage from the females, a distinction recognisable in most genera; they also have a "spur" on the metatarsus. The food of the scratching birds consists of grain, seeds, and insects, &c. They are provided with a strong muscular gizzard for grinding the hard food. Most Rasores build on the ground, the female or hen bird generally only taking part in the incubation. The young are precocious, and can feed almost as soon as they have escaped from the egg-shell. With the exception of the partridges and grouse the flight is very weak,—even the two mentioned cannot fly for any length of time. There is usually a fleshy comb or crest of feathers, and often naked and brilliantly coloured patches, on the small head. We never find, as in the Doves, a "cere" at the base of the bill.

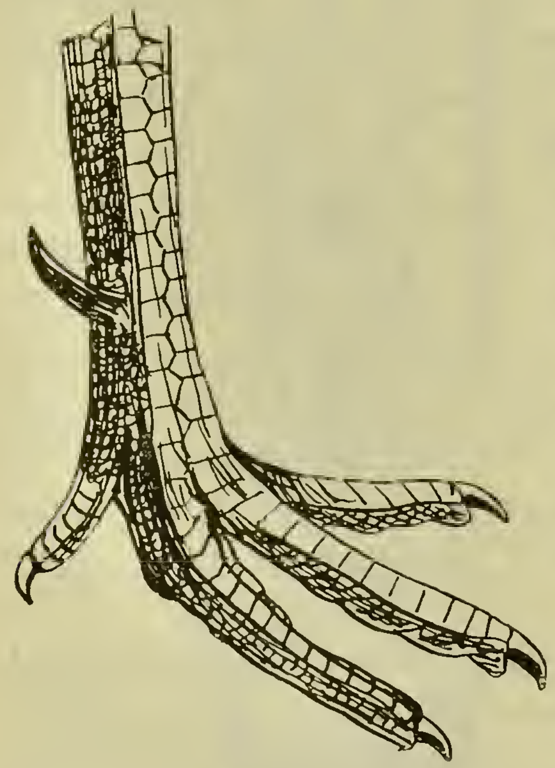

Fig. 221.—Foot of Gallinaceous Bird.

The two families of the Gallinæ are the *Phasianidæ* and *Tetraonidæ*.

The *Tetraonidæ* include the Grouse, Blackcock, and Capercaillie (*Tetrao*), and the Partridges (*Perdix* and *Caccabis*).

The *Phasianidæ* or Pheasant group include the Quail, *Coturnix communis;* the Fowls, *Gallinæ;* the Turkeys and Guinea-fowls, *Meleagrinæ;* and the Pea-fowls, *Pavoninæ.*

The two partridges are the *Common* or *Grey Partridge* (*Perdix cinerea*) and the *Red-legged* or *Frenchman* (*Caccabis rufa*).

The grey partridge is widely distributed over Great Britain, but is especially abundant in the eastern counties. It was said to be decreasing there, owing to the increase of the red-legged partridge; but this can scarcely be the case, for the two flourish side by side, and do not interfere with one another. In Ireland it is also said to be decreasing. They are subject to much variation in colour, according to the soil. Breeding takes place in February, and in April the hen lays from 12 to 30 or more eggs, which hatch out in three weeks.

The *French Partridge* (*C. rufa*) was introduced into England in 1770; from that date it has spread, and is now firmly planted in the eastern counties and some parts of the Midlands, &c. In the west it has taken no hold—in fact it thrives best on poor, bare, and dry lands. The red legs, rudimentary spurs, and running habits soon distinguish it from our native species. The eggs, too, are very different: those of *cinerea* are olive-brown, those of *rufa* are yellowish-white, blotched with rusty-brown.

The two species live, feed, and breed apart, and have no influence upon one another. The food of the grey partridge consists of insects, snails, weed-seeds, and grain; the red-legged partridge feeds especially on dry fallows and waste-land. Although some grain is destroyed by both, yet they may be said to do more good than harm, for countless insects and weed-seeds are eaten at the same time.

The Red Grouse (*Tetrao scoticus*) is indigenous only to the British Isles. It is generally distributed over the Scottish moors.

In England it is found from Yorkshire and Derbyshire down the Pennine Range as far as the Trent; it is also found in Staffordshire, Shropshire, Cheshire, Lancashire, and on many of the Welsh moors, especially in Merionethshire. It was introduced on Dartmoor and the Surrey heaths, but soon died out. They pair early in spring, making a rough nest near a tuft of heather. Young and old feed on the tips of the ling heather, and on bilberries, &c. This bird is much subject to diseases of various kinds.

The Blackcock (*T. tetrix*) is found on Exmoor and in South Devon, Somerset, Dorset, Wilts, &c. Farther north and in Scotland it is abundant. Blackcocks are polygamous, but separate from the females, the "Grey-hens," for a short time in the autumn.

The Capercaillie (*T. urogallus*) or Wood Grouse became extinct in England and Wales, and also in Scotland, towards the end of last century. It has been reintroduced into Scotland, and has spread from the pine to oak and other woods, being especially abundant in Perthshire.

The *Pheasant* (*P. colchicus*) is a native of Asia, probably having been imported by the Greeks into Europe from the banks of the Colchian Phasis, the modern Rion, which enters the Black Sea: certain authorities say it was introduced from some of the Asiatic islands. It is also abundant in the Caucasus, the Sea of Aral, and the Caspian Sea, and is said to occur in its wild state in Central Europe. From what we can gather, it was well known to the Athenians soon after 1200 B.C. From Greece it was transported to Rome. It was not until after the Crusades that it became familiar in England. But there is evidence that the pheasant was naturalised in the south of England before the Norman invasion. At the end of the last century the Chinese Ringed-neck Pheasant (*P. torquatus*) was introduced: this has bred with the original species to such an extent that we seldom get a pure-bred *P. colchicus* now, there being nearly always a trace of the white ring. The crow of the male may be heard in March when they are fighting for the hens. From 10 to 15 eggs are laid, generally in a slight nest on the ground. When flying their pace is rapid for a gallinaceous bird; but they seldom cover great distances. The average weight of a cock is from 3 to 3¾ lb. and a hen from 2 to 2½ lb. The pheasant as a game bird is most valuable, but to the farmer it is very destructive at times. Nevertheless, it does much good at others. The young feed on insects and small grain, but especially upon ants and ant-cocoons; but when adult they devour quantities of grain, peas, beans, turnip, red clover, and young wheat. They love, above all, buckwheat. Enormous numbers of wireworm and other insects are destroyed by the pheasant.

Domesticated Gallinæ.

Amongst domestic Gallinæ we must mention the fowl, of which we have now so many varieties, the Turkeys, the Guinea-fowl, and the Peacock. The first two of these domestic birds have been so altered under domestication that at least in one, the fowl, the origin is lost in obscurity, and even in the Turkey and Guinea-fowl some diversity of opinion exists as to the parent stock. Much light has been thrown upon this subject by Darwin in his renowned work on 'The Variation of Animals and Plants under Domestication.'

The Fowls belong to the genus *Gallus*, the Turkeys to the genus *Meleagris*, the Guinea-fowls to the genus *Numida*, and the Peacock to the genus *Pavo*.

The probable origin of the Domestic Fowls.—Where the original stock came from we cannot say with any degree of certainty. Remains of domestic fowls are found in the early "cave-fauna" of France, pointing, it would seem, to a European origin; but we find no traces in Europe of any wild Galli. The most eminent authorities have come to the conclusion that all our domestic varieties are descended from one species, the Jungle Fowl (*Gallus bankiva* or *G. ferrugineus*), sometimes called the Red Jungle Fowl, which is a native of continental India. When such a master-mind as Darwin's comes to this conclusion, the evidence must be satisfactory.[1]

There are four known wild Galli—viz., the Jungle Fowl of continental India (*G. bankiva*), the Jungle Fowl of South India (*G. Sonneratii*), the Jungle Fowl of Ceylon (*G. Stanleyi*), and the Forked-tail Jungle Fowl of Java (*G. furcatus*).

The *G. bankiva* or *G. ferrugineus* is found all over India where thick jungle exists, and extends into the Madras Presidency, where it meets Sonnerat's jungle fowl, and is said to interbreed with it; it also extends into Burma, Malayana, and to Timor. This bird is subject to considerable variation in different localities. Our black-breasted red game resemble it in most points save in that the tail of *G. bankiva* is carried horizontally whilst the game tail is carried erect. The chicks of *G. bankiva* are hatched in twenty days, and eggs are laid from January to July. There is not the least doubt but that the Burmese and Arakan breeds are descended from *G. bankiva*, having acquired by selection yellow legs and greater size.

The nearest ally to *G. bankiva* is *G. Stanleyi*, the Ceylon Jungle Fowl, which chiefly differs in that it has a yellow comb edged with red and a reddish breast. This species never lives in captivity for any length of time, a feature we may well note in connection with the origin of our domestic birds.

The Sonnerat Jungle Fowl (*G. Sonneratii*) is found in the south of India, and is distinguished by the flattened shafts of the hackle-feathers of the cock, which resemble spots of creamy sealing-wax. The crow is very peculiar, quite unlike that of the domestic cock or red jungle fowl, and the eggs are described as being of a pinky-cream colour. This species is not nearly so easily domesticated as *G. bankiva*, with which, however, it interbreeds both wild and in confinement.

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[1] The wild fowls of Fiji are descendants of the domestic poultry taken there by the early voyagers. These fowls now resemble the Red Jungle Fowl in appearance: they have reverted, that is, to the ancestral type.

The last species is the Fork-tailed Fowl or Javan Jungle Fowl (*G. furcatus*), which inhabits Java and some of the islands in the Malay Archipelago. The neck is metallic green, the saddle hackles orange with a brown centre, and the two central tail-feathers curved out in a forked manner; the comb is greenish-red or yellow, and quite clean at the edge, no serrations being seen. Numerous crosses with domestic fowls have been produced, and it is said that two other supposed species, *G. Temmickii* and *G. æneus*, have arisen in this way.

There is little doubt but that *G. bankiva* has given rise to the various domestic breeds, and may possibly have been helped to some extent by *G. Sonneratii*, these breeds having originated by artificial selection and breeding. The longer animals and birds are under domestication the more they seem subject to variation. By judicious selection it is quite possible through a long series of ages to have formed from a single type such diverse forms as the Bantam on the one hand and the Dorking on the other, or the tailless fowl of Holland and the long-tailed fowl of Japan.

The *Turkey* (*Meleagris*).—The ancestry of the turkey is less complex, but still is a matter of uncertainty. There are three wild turkeys—one common to Canada and the States, the so-called American turkey, *M. americana;* another is found in Mexico, *M. mexicana;* and a third in Guatemala and Central America generally, *M. ocellata.*

There is some doubt as to *M. americana* and *M. mexicana* being distinct species, some authorities considering them varieties: there is little difference except in colour, the Mexican species having white tail-coverts and tips to the tail-feathers. If they are distinct, there is little doubt but that our domestic turkeys are derived from *M. mexicana;* for both have the white in the tail, which is absent in the American turkey.

The Honduras or Ocellated Turkey (*M. ocellata*) is found in Guatemala and Yucatan. It certainly has no connection with our domestic forms, although hybrids of it have been known to breed in domestication.

The domestic turkey lays from fifteen to twenty eggs—generally sixteen is the number. They breed in the wild state on the prairies surrounding the large American forests, the hens leaving the "gobblers" during incubation. The latter are most pugnacious to any young they come across. We notice similar habits in our domestic breeds.

The *Guinea-fowl* (*Numida*).—All wild guinea-fowls are found in Africa or Madagascar. The following wild forms are known:—

Numida meleagris, the West African Guinea-fowl, found on the coast of Gambia. *N. ptiloryncha*, the Abyssinian Guinea-fowl, found in Eastern Africa. *N. mitrata*, the mitred Guinea-fowl of South Africa. M. *tiarata*, in Madagascar, probably only a local race. All the above have a bony casque.

N. cristatus, the Crested Guinea-fowl of West Africa. *N. Pucherantii*, in Zanzibar, probably only an Eastern form of *cristatus*. *N. plumifera*, the Plumed Guinea-fowl of West Africa. All the last three have a plume of feathers in place of a casque. And, lastly, there is the quaint *N. vulturina* or Vulture Guinea-fowl, found in Eastern Africa.

Our domestic species is said by some to be descended from the West African species, *N. meleagris*, which extends from Gambia through Ashantee to Gaboon, and is also found in the Cape de Verd Islands. More probably it is from the Abyssinian guinea-fowl that ours have come, as it was a bird well known to the Romans, and they had constant intercourse with its native haunts *viâ* Egypt.

The guinea-fowls take from twenty-six to twenty-eight days to incubate. They are extremely shy, although long under domestication, and are of the greatest service to fruit-growers, if kept in orchards, where they devour large numbers of grubs and larvæ that fall to and are on the ground. The males are spurless. Naturally the guinea-fowl is monogamous, yet we often find one cock amongst several hens. White varieties are frequently seen.

The *Pea-fowl* (*Pavo cristatus*).—The pea-fowl is a native of India and Ceylon. Only three species seem to be known—our common domestic one, the Javan species (*P. muticus*), and a black-winged species (*P. nigripennis*). These birds have a crest of feathers on the head, and the male has some of the back-feathers and the upper tail-coverts of considerable length and ocellated. The pea-fowl was well known to the ancients from the time of Solomon. It is looked upon with veneration by the Hindoos, and in many States is not allowed to be shot. They live to ten and twelve and even more years old, and look after their young through the winter. Incubation lasts twenty-eight days. It is said that they were introduced into Europe by Alexander the Great. There is little or no difference between our tame ones and the wild birds of India at the present day, with the exception that white varieties are found under domestication.

9. Gruiformes.

Rails and Coots (Ralli).

The Rails or Crakes, Moorhen, and Coots are included in the family *Rallidæ*. They are strong-legged, active-running birds, some being aquatic in habits. The best-known example is the Moorhen (*Gallinula chloropus*).

The *Moorhen* or Water-hen is a resident bird with us, but partial migrations take place in very severe winters from north to south. The upper plumage is dark olive-brown; head, neck, and belly slaty-grey, with white streaks towards the legs; the under tail-coverts are white; base of bill red, rest yellow; legs yellowish-green with a red band around them above the tarsal joint. The female moorhen is larger than the male, and often brighter in colour. The young differ chiefly in having a greenish beak and legs and a white throat. The nest is built in a variety of places—amongst reeds and water-plants as a rule; but they are sometimes found on trees some height from the ground: boughs overhanging the water are also favourite resorts. The material mainly consists of dried sedge and reeds. Sometimes the nests reach a foot or more in height when the level of the water has risen, the birds adding to the nest to stop it being flooded. As many as ten eggs may be laid, but seven or eight is the usual number. They commence to build early in March, and, as a rule, have two broods in the year, but even three are not unusual. It is said that the young of the first brood help the parents to prepare the second nest. Their food consists of water-insects, slugs, snails, and various land insects; but at times they will attack seed-corn, and where very abundant may now and then cause slight loss.

The *Coot* (*Fulica atra*) has a lobate foot, and is sooty-black in colour, rather greyish above, with pink beak and a large white bare patch on the head. The nests are huge floating structures, often large enough to support a man.

The Rails, of which the Landrail or Corncrake (*Crex pratensis*) is the best known type, are all noted for their running powers. The corncrake appears in England in April in the south, later as we proceed north. Pasture lands, especially when put up for hay, are their favourite resorts; but numbers also go to cornfields, where they feed off insects and weed-seeds. The nest is placed in long grass and in standing corn, and is frequently found in the former during mowing. Like all the crakes, this bird will feign death when captured. It runs with great rapidity amongst the grass, and thus we hear its harsh note, as it seems, all over the field.

10. Charadriiformes.

Plover, Snipe, Sandpipers, &c. (Limicolæ).

Of the four families of the Limicolæ—the *Œdicnemidæ* or Stone Curlews, the *Glareolidæ* or Pratincoles, the *Charadriidæ* or Plovers, and the *Scolopacidæ* or Snipe, Woodcock, Stints, Sandpipers, Redshanks, &c.—the last two only need be referred to. These birds were at one time united with others to form the order of "Waders" (*Grallatores*).

The *Charadriidæ* or Plovers have the bill compressed at the tip and seldom longer than the head. The toes are short and the hind one (hallux) absent or very small. The plovers can both run and fly fast. Their food consists mainly of animal substance, such as worms, snails, slugs, and insects, which they hunt for in meadows and marshes and on mud-flats. The young are precocious. The eggs are laid, with little nesting substance, on the ground. Some are partially migratory, such as the Dotterel (*Eudromias morinellus*) and the Golden Plover (*C. pluvialis*). The commonest species is the Lapwing (*Vanellus cristatus*).

The Lapwing is also called the Peewit or Green Plover. It is generally distributed throughout Great Britain, and is, as a rule, resident; but migrations take place from the north to the south in very cold winters. Numbers also arrive from the Continent in the autumn. The lapwing is partial to marshy lands and moorlands, and may also be seen feeding in numbers on mud-flats. The curious curved crest of feathers on the head at once identifies it. Head, crest, and breast are glossy black; throat, neck, and abdomen white; the back dark-green and metallic; tail black and white; legs and feet orange-red; bill dull reddish-brown. The female does not differ much from the male, but the young birds have the dorsal feathers edged with buff and the crest shorter. The nest is formed in a depression in the ground, especially in pasture and fallow lands; a few pieces of grass and stalks are added during incubation. The eggs are laid from the end of March to June, the majority in April. Four or five are laid in each nest; they are olive-green with dark-brown blotches, but may have a grey or even blue ground-colour. The female when disturbed runs rapidly away from her nest, the male at the same time rising and twirling about in the air, uttering its shrill note to allure the enemy from the nest and young. Like most birds in this group, the eggs are laid crosswise. In winter the peewits collect together in flocks and sometimes fly great distances in lines. Migration in this country is chiefly after food. The eggs are much sought after for the table in spite of the Wild Birds Protection Act, and yet this is one of our most useful birds. Their food consists of wireworms and all manner of larvæ and insects, also worms. The large flocks—for they are gregarious even in the breeding season—must tend largely to the destruction of many noxious farm pests.

The *Scolopacidæ* include the Woodcock and various Snipe, the Ruff, Sandpipers, and Curlews, &c. They are all provided with long bills, which may be straight or curved; the three forward toes may be partially webbed as in the Avocet (*Recurvirostra avocetta*), or lobed as in the Phalaropes (*Phalaropus*), or united at their base by webbing as in the Curlew (*Numenius arquata*), but many are free. The legs are usually long and slender and adapted to wading (fig. 222). The basal webbing of the foot is not shown in the figure.

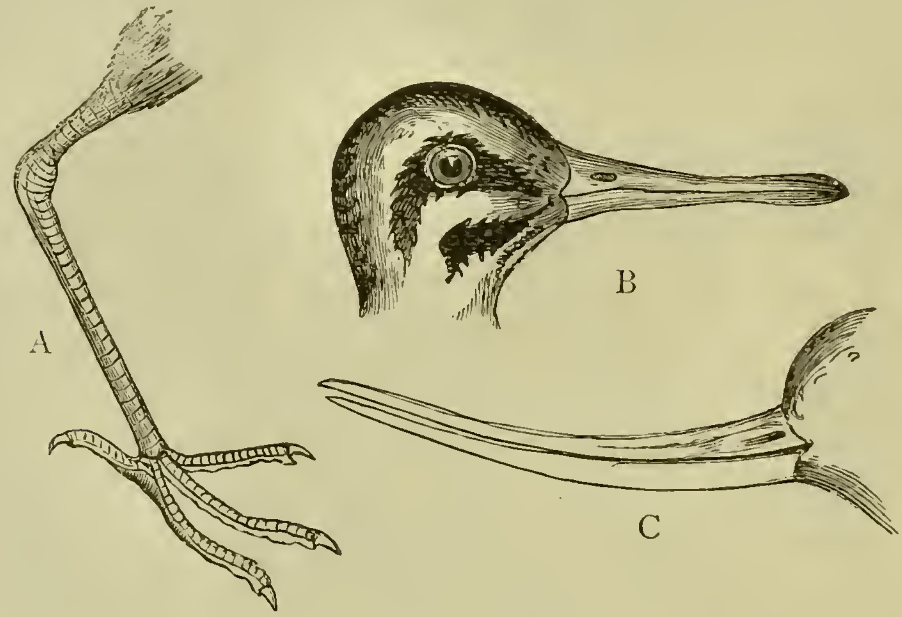


FIG. 222.—SCOLOPACIDÆ.

A, Leg and foot of Curlew; B, Head of Snipe; C, Beak of Avocet. (Nicholson.)

GULLS AND TERNS (GAVIÆ).

The Gulls and Terns are united into one family, the *Laridæ.* They have long wings and either knife-like or hooked bills. The three front toes are always webbed, and the fourth is often very small. The true gulls (*Larus*) are the only ones we need refer to. In this genus the fourth toe is placed high up on the metatarsus; the three front toes are entirely palmate. The bill has a sharp cutting edge, hooked at the tip of the upper mandible. The tail is square at the end. Gulls are normally fish-eaters, feeding upon surface-fish and dead fish along the coast; garbage of any kind is also devoured by them. Very often, however, several of the *Laridæ* pass many miles inland and live upon various insects, especially such destructive larvæ as wireworm, leather-jackets, and cockchafer grubs. They may often be found, preceding and during stormy weather, sixty and seventy miles inland, following the plough as readily as the rook, and devouring with avidity the grubs turned up during its progress across the fields. These birds usually appear inland, as on the coast, in flocks. Most species breed on the coast, but some, such as the Black-headed Gull (*Larus ridibundus*), breed inland on the banks of lakes and rivers and in marshes. The young are nestlings. The Herring Gull (*L. argentatus*), as well as the Common Gull (*L. canus*), must also be included amongst those whose services are beneficial to us. Small mammals, such

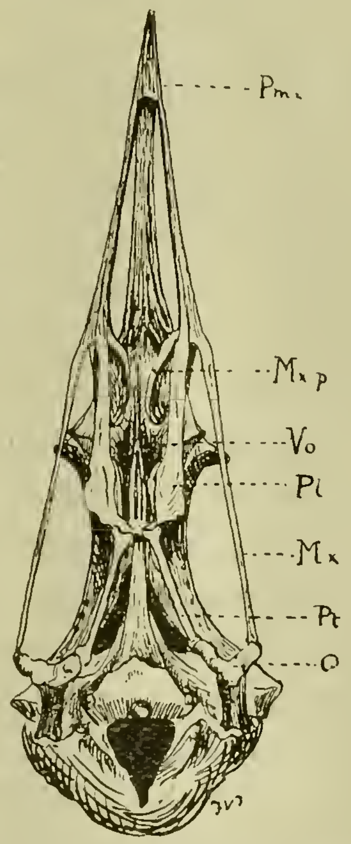


FIG. 223.—SKULL OF A GULL (Larus), Schizognathous type.

Pmx, Premaxillary; *Mx.p*, maxillo-palatine; *Vo*, vomer; *Pl*, palatine; *Mx*, maxilla; *Pt*, pterygoid; *Q*, quadrate.

as mice, voles, and shrews, also form part of their bill of fare when driven by stress of weather inland.

The *Black-headed Gull* (*L. ridibundus*).—This gull is very different in plumage in summer and winter. In summer the head and neck of both male and female are dark-brown; in winter this coloration has quite gone, those parts being pure white. In spring the brown colour again appears. This change is not due to a fresh moult, but to an actual change of colour in the existing feathers. The legs and bill are bright red. The young birds have quite a different plumage, being much darker, the dark-brown feathers being mottled at their edges with yellow, and the feet yellow, not red. This gull breeds inland on marshes and flats as well as along the coast, and it is especially during the breeding season that they destroy so many noxious insects. The nest is made by trampling down a number of reeds, grass, and sedges; in this concavity during April and May three dusky-olive eggs spotted with black are laid.

The *Herring Gull* (*L. argentatus*).—This gull is one of our largest species, often reaching two feet in length. The head and neck are white, often in summer with brown streaks; the wings and the back are pale bluish-grey, the primary feathers being black and grey with black shafts and white tips, and the secondary feathers also edged with white. The bill is yellow and the feet light pink. The herring gull builds its nest on steep cliffs and rocks, in which are deposited three olive-brown eggs spotted with dark brown. This gull is one of the commonest that we see following the plough in the south of England, and seems especially fond of the large soft chafer larvæ.

The only other gull seen abundantly in our fields is—

The *Common Gull* (*L. canus*).—The common gull justly deserves its name, for it may be found all round our seaboard and often abundantly inland. It is not so big as the herring gull, seldom attaining a greater length than eighteen inches. The head and neck are white with dusky spots, ventral surface and tail white, the back bluish-grey, the two first primaries black with a large white space near the extremity, the tip quite black. The bill is dusky-green at the base, yellow at the tip, and the feet greenish-grey. The young have the bill almost black with a yellow base, and dusky-yellow feet. It breeds chiefly on rocky coast-lines, but may resort to marshes to rest. This species commingles with the herring gulls, rooks, and peewits in the ploughed fields, and does much good by devouring numerous larvæ.

These three gulls should be well protected, as they are decidedly friends of the farmer.

11. Columbiformes.

Doves and Pigeons (Columbæ).

The Columbæ are endowed with strong wings and great powers of flight. The feet are slender and adapted for perching. They are all monogamous, and pair for life or some time. The beak is weak, with a cere at the base and thin scales over the nostrils. The young are quite helpless for days after they are hatched—nestlings. They are fed by the parent first with a cheesy substance excreted by the glands of the crop, then by soft food from the crop itself. The nests are formed in trees and on rocky places, sometimes in holes in decaying trunks: they are flat structures composed of loosely united twigs upon which the longish, shiny white eggs (two in number) are laid. There are four species found in England—the Wood-pigeon (*Columba palumbus*), the Stock-dove (*C. œnas*), the Rock-dove (*C. livia*), and the Turtle-dove (*Turtur communis*).

All pigeons have long and powerful wings, and can fly immense distances. The sense of sight is extraordinarily keen. Most species feed on the ground, but do not scratch about like fowls (*Gallinæ*), nor do they usually dust themselves in so-called "dust-baths"—they prefer water in which to clean themselves.

They differ again from fowls in drinking: the fowl takes short draughts, holding up its head between each sip; the pigeon takes one long bibition, its beak immersed in the water the whole time. Pigeons feed exclusively on vegetable food. In the genus *Columba* the base of the upper mandible is covered with a soft skin in which the nostrils are pierced, and the twelve tail-feathers are nearly even. In *Turtur* there are two tumid soft substances at the base of the upper mandible covering the nostrils.

The *Wood-pigeon* (*C. palumbus*) does much damage. It is also known as the ring-dove and the queest. Its recent increase is due partly to the killing off of all the large birds of prey and to the increase of coverts. It is most abundant on our eastern coasts, where large numbers arrive from the Continent. They commence to breed in April; a second nest is formed in June, and a third even in October. The nests are placed in all manner of places—on high trees, in ivy, and on low bushes. Incubation lasts eighteen days, and the young are blind until the ninth day. The male sits all day, the female of a night. They unite in large flocks after the breeding season is over. In spring and summer they are seen in pairs: at this time they feed on the young leaves of peas, beans, and corn; and turnips when young are also greedily devoured. Often whole fields of peas are spoilt by them. In winter they go to the woods in flocks and feed on beech-nuts, acorns, &c.; even then they do not neglect foraging expeditions to the fields, where cabbage and rape suffer from their incursions. It is not so much those wood-pigeons that breed with us that do the damage, as the large flocks that come from abroad in the winter and leave us again in the spring. These foreigners can be told from our natives by their smaller size. We must not forget, however, that they eat numbers of weed-seeds, and so do some little good in return for the harm they occasion, but they are far too abundant.

The *Turtle-dove* (*T. communis*) visits us only in spring, and remains until the end of September. They come from South Europe, Palestine, and elsewhere in Asia. This beautiful dove extends into our midland counties, but seldom farther north then Sheffield. Many a time have I watched them returning from the wheat-fields and flying off to some belt of trees, where they nest. They have not been eating the corn, but the seeds of the numerous weeds on the ground, especially the seeds of the corn-spurrey (*Spergula arvensis*) and the docks (*Rumex*): they are thus benefiting the farmer. At times they may do slight harm: for instance, vetch-seeds are greedily eaten, so also is buckwheat; but their chief food consists of weed-seeds, as has been many times tested by examining their crops. The nest is a slight structure, generally on the lower branches of trees and in high bushes. The eggs are laid in May and June and even July, incubation lasting about sixteen days, both cock and hen taking part in it. The tail-feathers are broadly edged with white, which renders them very conspicuous when flying. The male has the head, rump, and flanks bluish-grey, with a patch of black-and-white feathers on each side of the neck; throat and breast pale wine-red.

The *Rock-dove* (*C. livia*) is of much interest, as it is the original form of our numerous domestic pigeons, a fact clearly demonstrated by Darwin. They breed in a few parts of the rocky shores of the coast of Great Britain, and are found in most parts of Europe. Like all our domestic pigeons, they seldom will settle on trees. Even in the high state of domestication of our fancy birds the love of rocky places still exists, for they always fly to ledges of houses, churches, &c., when free, and there, like their early progenitors, form their nest. Rock-doves are very scarce in England, breeding only in a few coast localities, notably Flamborough Head and in Devonshire. Numbers of the following species also breed on the south coast of Devonshire, and may be mistaken for *C. livia*. The white rump, the white under wing-coverts, and the two very distinct bars of black across the wings, easily distinguish it. In many respects it resembles the common blue-rock.

The *Stock-dove* (*C. œnas*) nests in the stocks of trees and even in rabbit-burrows. It may be found abundantly in well-timbered districts in the middle, west, and south of England, and nests about March, but also right through to October. It can be told from the Wood-pigeon by the absence of the white-and-black neck-mark, and by the under-side being bluish-grey; there is also an imperfect black bar on the wing, and the under wing-coverts are grey.

12. Cuculiformes.

Cuckoos and Parrots (Cuculidæ and Psittaci).

The *Cuculiformes* are the Cuckoos and Parrots. The former alone are represented in these islands, and by a single species only, the *Cuckoo* (*Cuculus canorus*). This bird comes to us about the beginning of April, when it soon proclaims its presence by its well-known note. It is found throughout Great Britain. The female cuckoo lays her egg on the ground, and then by means of her bill she carries it to some nest to be incubated. For this purpose she specially chooses the nest of a reed-warbler, meadow-pipit, wagtail, or hedge-sparrow. The young cuckoo grows rapidly, and soon turns out the proper occupants of the nest, by means of a cavity on its back, which then grows up, commencing to disappear about the end of the second week after birth. The food consists mainly of insects, the foster-mother being kept busily at work, as the young cuckoo is ravenous. Hairy caterpillars of the lackey-moth, tiger-moth, &c., are especially acceptable to the young bird. It is a widely distributed bird, being found in India and Africa and many other parts.

13. Coraciiformes.

(i) Owls (Striges).

The Owls or *Strigidæ* are nocturnal birds of prey, with very soft plumage, and with raptorial feet in which the fourth toe is reversible. The eyes are directed forwards, and are large in size. The beak, which is short, is furnished with a number of bristles at its base, and the nostrils are pierced in the cere. The head is large, owing to the cranial bones being hollow, and the eyes are surrounded by a disc or veil of feathers. The ear is also surrounded by feathers and protected by a fold of skin. The undigested food, as in the Falconidæ, is passed out in pellets from the mouth. Striges have a wide gullet, but rather small stomach. There are nine genera recorded in Great Britain. The four common British species are the Barn-Owl (*Strix flammea*), the Long-eared Owl (*Asio otus*), the Short-eared Owl (*Asio accipitrinus*), and the Tawny Owl (*Syrnium aluco*).

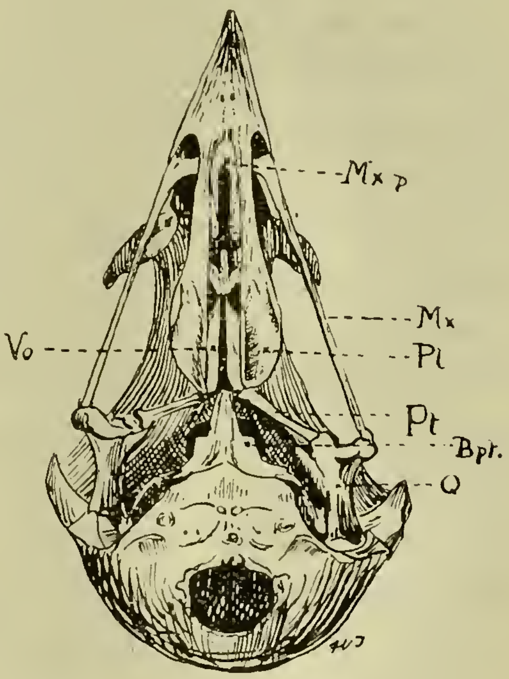


Fig. 224.—Skull of Owl (Schizognathous, with Desmognathous tendency).

The *Barn-Owl* (*S. flammea*) is common in most districts of England, Ireland, and Wales, but less so in Scotland. This useful bird takes up its abode in sheds and out-buildings, in church-towers and hollow trees, where it remains concealed during the daytime. The back of the male is pale orange, variegated with grey and white; beneath the plumage is white, and so are the discs, which are edged with orange; the bill is white, and the legs are clothed in soft white feathers. Some specimens are much darker in plumage than others, a few quite dark forms existing. The owl makes no nest, but just lays her dull white eggs in pairs in April and May, and even later. It hunts for its food at dusk, flying almost noiselessly along the hedgerows. Its food consists of mice, rats, shrews, bats, and various large insects. No harm whatever is done by the barn-owls, and yet gamekeepers and many farmers persist in killing them although they are their friends, and, having slaughtered as many as they can, marvel at the increase of rats and mice!

The *Tawny Owl* (*S. aluco*), which in some places is quite as common as the barn-owl, has the back shaded with ashy-grey mottled with brown, the tail barred with brown and tipped with white; the lower plumage is yellowish-white streaked and mottled with pale and dark-brown; discs grey with a dark-brown border; legs and feet have hairy feathers all the way down to the claws. The female is more red-brown in colour. They lay their eggs in hollow trees and rooks' nests, as well as in similar places to the barn-owl. If anything the tawny-owl is more useful than the preceding species—voles, rats, mice, and all kinds of vermin being taken by it. It is especially abundant in woody districts, and is sometimes called the Wood-owl.

Both Short- and Long-eared Owls (*Asio accipitrinus* and *A. otus*) are common in this country, the former especially in open, moorland tracts, but often over turnip- and stubble-fields. Numbers come from the Continent in the autumn. It seldom breeds here. Unlike most owls, the "short-ear" will take its prey in the daytime. Mice, rats, birds, and reptiles, also insects, are taken by it, and it is said fish also. It may often be put up in the autumn when shooting, and flies off with great rapidity. The Long-eared Owl is chiefly found in fir plantations. There it hunts for its prey during the night, and clears off much vermin. Although fairly common all the year, it is much more so in autumn, owing to migrations from the Continent. It breeds in old birds' nests and squirrel-dreys.

All the owls may be said to be decidedly useful birds, and the practice, still largely in vogue, of shooting them down should be prohibited by all landowners and farmers.

(ii) MACROCHIRES.

SWIFTS (CYPSELIDÆ).

The Swifts have all four toes directed forwards, and provided with long and strong claws. The bill is short and wide, the gape extending very far back, beyond the eyes. The nostrils are longitudinal, the borders being edged with small feathers. The wings are very long and pointed, and the tail forked in the genus *Cypselus*. Swifts were formerly classed with the Swallows, but are now shown to be related more closely to the Nightjars, still more closely to the Humming-Birds.

Cypselus apus, the Common Swift, is an abundant summer visitor, appearing annually about the end of April, and leaving about the end of August. The colour is blackish-brown, more or less shiny, with a pale-grey or white area under the throat. They make their scanty nests in holes in thatch, in church towers, crevices in cliffs and quarries, &c., in which they deposit two white eggs in June. The Swifts are very useful birds, as they devour numbers of insects, especially moths.

NIGHTJARS (CAPRIMULGIDÆ).

The only representative in England is the Goatsucker or Fern-Owl (*Caprimulgus europæus*), a migrant which arrives in England about the middle of May. They have an extremely wide gape, the edges of the mouth being furnished with a row of bristles. Insects, such as cockchafers and moths, form the greater part of their food, which they catch whilst flying about at dusk and during the night. The nightjar lays its eggs upon the ground in open places amongst fern and gorse and in wood clearings.

(iii) Coraciæ.

Kingfishers (Alcedinidæ).

One species only occurs here—namely, *Alcedo ispida*, which is a resident bird, generally distributed over Great Britain. It delights in lakes, ponds, rivers, and even the sea-coast, darting about in straight lines, and suddenly plunging from its perch into the water to secure some unwary fish, upon which it lives. Dragon-flies and beetles are also eaten. The beautiful azure-blue back and dark-blue tail and chestnut breast and belly make it a conspicuous object. The nest is made in a hole in the banks of pieces of water and rivers. The eggs are laid on a layer of fish-bones.

Three other groups are represented in this section, by the Roller (*Coracias garrulus*), Bee-eater (*Merops apiaster*), and Hoopoe (*Upupa epops*), but they are only casual visitors.

(iv) Pici.

Woodpeckers and Wrynecks (Picidæ).

The Picidæ have the hallux and fourth toe turned back, the second and third forwards (fig. 225).

Three Woodpeckers occur in Great Britain,—the Great Green Woodpecker (*Gecinus viridis*), the Great Spotted Woodpecker (*Picus major*), and the Lesser Spotted (*P. minor*). The Woodpeckers hammer out holes in trees in which they form their nests. The green woodpecker cuts out a neat circular hole, by choice in a soft-wooded tree—this tunnel running in as far as the hard central wood, and then turning downwards at right angles, where a large chamber is formed, in which the

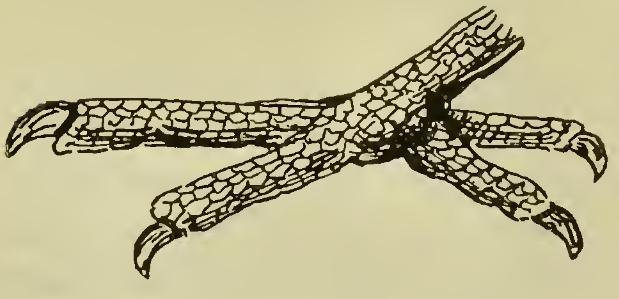


Fig. 225.—Scansorial Foot, as seen in Woodpeckers and Parrots.

five to seven eggs are laid on a bed of wood-chips. There is a new nesting-hole formed every year. Sound as well as decayed trees are attacked; but the good the green woodpecker does in destroying injurious insects makes up for the harm it does to a few trees. They feed almost exclusively on insects, especially the larvæ of wood-boring beetles, which we see them hunting for up the tree-trunks. The stiff feathers of the tail help them in their progress up the trunk. Ants and other ground-insects are also eaten by *G. viridis*, it being no unusual thing to see them hunting on the ground. This handsome woodpecker has green upper plumage, greyish-green under plumage, and bright crimson crown and nape.

The Great Spotted Woodpecker (*Picus major*) and the Lesser Spotted (*P. minor*) also live in a similar way, and feed off wood-destroying insects.

The Wryneck (*Yunx torquilla*) is allied to the Woodpeckers, and makes its nest in a hole formed in a tree like the other Woodpeckers. Its food consists mainly of insects, which it licks off by means of its long extensile tongue covered with a glutinous saliva.

14. Passeres or Passeriformes.

The last remaining group includes the majority of our birds. They have fourteen or fifteen cervical vertebræ, and the second, third, and fourth toes are always turned forward. The brain is more fully developed than in other birds, and the organ of voice is most highly organised. The chief families are the Larks (*Alaudidæ*), the Rooks, &c. (*Corvidæ*), the Starlings (*Sturnidæ*), the Finches (*Fringillidæ*), the Wagtails (*Mota-*

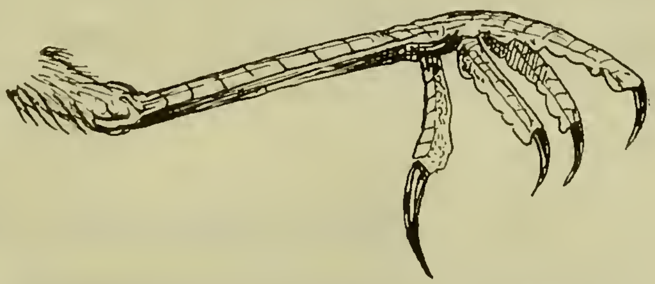


FIG. 226.—FOOT OF PASSERINE BIRD (Wagtail).

cillidæ), the Flycatchers (*Muscicapidæ*), the Tits (*Paridæ*), the Swallows (*Hirundinidæ*), the *Turdidæ* or Warblers (*Sylviinæ*), and the Thrushes (*Turdinæ*).

All these *Passeriformes* or Perching Birds have thin legs, and the males are usually more brilliantly coloured than the females. The young are nestlings, and are quite blind when hatched, being fed by the parents. Both cock and hen take a share of incubation. Their food and habits, as we shall see, are both very varied.

TRUE OSCINES (*OR SINGING-BIRDS*).

THE ALAUDIDÆ OR LARKS.

The Larks have their bill in the form of an elongated cone, the upper mandible slightly curved, with no notch; the oval nostrils at the base of the bill partly covered with feathers, and the head-crest capable of being erected. The hind-claw is also extremely long and nearly straight. The commonest English species are the Skylark (*Alauda arvensis*) and the Woodlark (*A. arborea*). The Larks mainly feed upon grain, but also take insects for their young. They frequent open fields, where they form their nests on the ground. During very cold weather, when they unite in flocks, they sometimes commit great havoc in gardens, eating the leaves of winter vegetables. They are augmented by vast arrivals from the north, and from the Continent in autumn. Larks dust themselves to get rid of the numerous lice parasites, a habit common to many Passeres.

CROWS, ROOKS, &c. (CORVIDÆ).

The Jackdaw (*Corvus monedula*), the Carrion Crow (*C. corone*), the Hooded Crow (*C. cornix*), the Raven (*C. corax*), the Rook (*C. frugilegus*), the Magpie (*Pica caudata*), and the Jay (*Garrulus glandarius*), are members of the *Corvidæ*. The jackdaw, crow, rook, raven, and hooded crow belong to the genus *Corvus*, which is characterised by the following: beak hard, stout, straight at base, and sharp at edges; the wings long; nostrils hidden by stiff feathers.

The Magpie belongs to the genus *Pica*, in which the beak is slightly notched at the tip of the upper mandible, and the wings are short and rounded. The jay belongs to the genus *Garrulus*, in which the beak is shorter than the head.

The *Carrion Crow* (*C. corone*) is black like the rook; the beak is strong and bent at the end; it has black feathers at the base, there being no white as seen in the rook. *C. corone* breeds in trees, usually at a great height. The young, which are hatched out very early—usually whilst other birds are laying—are most voracious. It is especially at this time that the crow does so much damage. They rob the nests of game-birds both of their eggs and young; poultry, leverets, and lambs have even been known to be attacked, whilst they are said to have killed ewes detached from the flock. With this food they feed the young, often carrying the bones and *débris* away some distance, so that their nests should not be detected. They apparently pair for life. The crow flies either singly or in pairs, never in large flocks as we see the rooks in England, although it is said to do so abroad. The only good one can see that they do is to

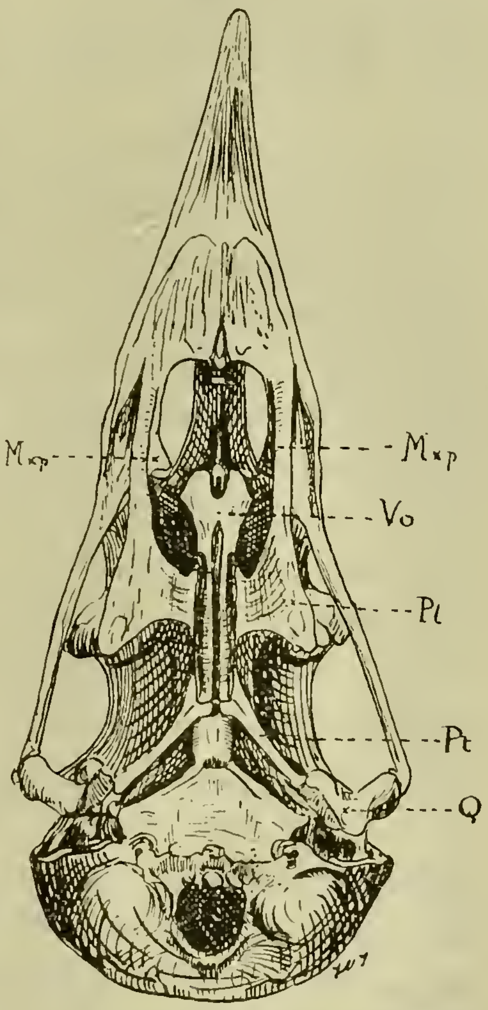


FIG. 227.—SKULL OF RAVEN, reduced (Ægithognatous).

Mx.p, Maxillo-palatine; *Vo*, vomer; *Pl*, palatine; *Pt*, pterygoid; *Q*, quadrate.

destroy carrion on the sea-shore and on land, and to keep in check the voles and field-mice, which they devour in numbers. They must, however, be recorded amongst our harmful species. Yet it is doubtful if it is wise to persecute them too far, for then we get rabbits and small mammals increasing to excess.

The *Rook* (*C. frugilegus*) is, on the other hand, very beneficial. The rook can at once be told by the white mark at the base of the bill. Moreover, the rook is gregarious, flying about and nesting in large companies. The main food of the rook consists of insect grubs, especially wireworm, leather-jackets, and cockchafer larvæ. Wherever we see rooks collected in the fields, there we have a sure sign of insect infestation. Nevertheless they are often ruthlessly destroyed, for it is said they do so much damage. What damage do the rooks do? They pull up roots and leave them dying on the ground, they eat grain, and they carry off large numbers of walnuts. Certainly in the last two instances they are harmful, but not to any great extent. The plants they pull up are not pulled up out of pure mischief, but to get at the wireworm biting at the roots; *this* they devour: they thus destroy one turnip and one wireworm. How many turnips and other plants would the wireworm destroy in its three or even five years of life? Some hundreds of thousands, and thus by killing the pest the rook must be saving all those future doomed plants that come in the wireworm's way. It is said that there are too many rooks, and thus their number must be kept down. This cannot be correct. If rooks are injurious, then kill them off entirely. It costs no more to scare 1000 rooks than 10. If 10 do good, then 1000 do so much more. Moreover, grain can be well preserved by mixing the seed with tar. If rooks and the like are killed we should have but little corn, for man cannot control, as yet, soil-grubs in the field.

The *Jackdaw* (*C. monedula*), which is much smaller than the rook and told by the grey colour of the back of the head and nape of the neck, is often found in company with it. They accompany rooks to their feeding-grounds, and nest if they can somewhere *near* rookeries and the haunts of men. The most favourite nesting-places are hollow trees, cliffs, and church towers. Jackdaws feed upon insects, grubs, fruit, and all manner of strange objects, which they delight to obtain and destroy. On the whole, they too may be considered useful birds to the farmer.

The Magpie (*Pica caudata*) and the Jay (*Garrulus glandarius*) are both harmful to some extent, eating not only insects but the eggs of many of our insect-feeding birds, ducklings, chicks, and game, grain, cherries, as well as wild fruits. Voles make up the bill of fare. The magpie is found in open country; the jay, with its harsh screaming note, in woodland tracts, where it falls a ready victim to the gamekeeper's gun, and it certainly is a pest in fruit and garden land.

STARLINGS (STURNIDÆ).

The genus *Sturnus* has a bill as long as the head, the edges of the upper mandible extending over those of the lower mandible.

The Starling (*S. vulgaris*) needs no description. The young, however, might escape our notice, for they are very different in plumage to the adult. The young starling is uniform ashy-grey without any spots, and has even been described as a distinct species by older writers. Starlings, especially after the breeding season, unite in large flocks, which fly at early morn to their feeding-grounds, and may often be seen accompanying the rooks and jackdaws. The nests are formed in holes in trees, walls, dovecots, chimneys, &c., in which are found five to seven pale greenish-blue eggs. The whole family of young and parents unite with others to form the flocks, and these break up again in the spring for nesting. During their foraging expeditions they feed on all manner of insect grubs, which form their chief food. Ticks on sheep are greedily devoured by them. On the other hand, they cause much harm in orchards, cherries being particularly damaged by them, as well as other soft fruit. On the whole, they do much more good than harm. Amongst the insects they are partial to are grasshoppers, wireworm, larvæ of moths, weevils, and plant-lice; slugs and worms are also eaten.

Finches and Buntings (Fringillidæ).

The Finches and Buntings form the family Fringillidæ of the Passeres, the former being included in the sub-family *Fringillinæ*, the latter in the sub-family *Emberizinæ.*

The Finches are remarkable for their short, thick, and powerful beak, the upper and lower mandibles being about the same size, so that the beak when closed forms a short thick cone. All the Finches are small, great numbers of species being found. The food consists largely of seeds, grain, and fruits; but some are large insect-eaters, and all more or less feed their young on insect life.

The Buntings have both mandibles incurved at the edges, the upper one being slightly smaller and with a hard bony knob.

The following are the more important British *Fringillinæ*: the Bullfinch (*Pyrrhula*), Linnets (*Acanthis*), Chaffinch (*Fringilla*), Sparrows (*Passer*), the Goldfinch (*Carduelis*), and the Greenfinch and Hawfinch (*Ligurinus* and *Coccothraustes*).

The genus *Pyrrhula*, which contains our common bullfinch, is characterised by the hard short bill, which bulges at the sides, the upper mandible being longer than the lower and thus overhanging its point.

The *Bullfinch* (*Pyrrhula europæa*) is one of the most destructive birds. Handsome as it is, we cannot say a word against its destruction, for the damage caused by *Pyrrhula europæa* in orchards and gardens is often tremendous. In the spring they commence to attack the blossom-buds of the fruit-trees—cherries, gooseberries, plums, and apple being particularly chosen. The ground beneath the trees is often found covered with the scales of the blossom-buds, showing the havoc they have wrought. We have frequently examined the buds of fruit-trees being attacked by these birds, but have never been able to find any sign of insect or mite within, so they do not pick them off for the same reason as the tits. They nest in thick copses and hedges, forming the nest of fine twigs and dry grasses, and lining it with fine fibrous rootlets, in which they lay five light greenish-blue eggs, streaked and speckled with reddish-brown and purple.

The female alone takes part in the incubation. The young are fed partly on insects and their larvæ, and seeds softened, it is said, by the female. Various seeds also form the food of the adult, such as those of the chickweed, thistle, plantain, and groundsel. It is needless to give a description of the bird, as it is so well known; but the young may be pointed out as differing from the adults by having no black on the head.

The *Linnet* (*Acanthis cannabina*).—The Linnet is widely distributed in England and Wales. In Scotland it is replaced by the Mountain Twite (*A. flavirostris*). In colour the linnet is very variable: the head in the male is mottled brown, red in the centre; back chestnut-brown, dull brown towards the tail, which is black, the outer tail-feathers bordered with white; primary wing-feathers black, bordered with white and tipped with ashy-grey; breast-feathers reddish-brown, edged with yellowish-red; abdomen dull-white, flanks reddish-yellow; bill horn colour, legs brown. In summer the beak is bluish-brown in colour and the feathers of the crown greyish-brown, tipped with crimson, the back being bright chestnut-brown. The linnet nests on commons and heaths, especially in gorse and juniper bushes and low hedges, about the middle of April. Four to six eggs are laid in the wood-lined nest, of a bluish-white colour, speckled and streaked with reddish-brown and purplish-grey. There may be two broods in the year. In autumn they unite into large flocks, and may be seen flying with a curious dipping motion over the stubble, which they work for their food. Mustard, rape, charlock, and other oily seeds are preferred by them, also thistle and dandelion seeds, whilst insects are now and then eaten: amongst other seeds we may mention flax, hemp, docks, and corn occasionally. The residents are augmented in autumn by large numbers that come from the Continent to the east coast, and by others that migrate southwards. In spring these flocks break up and they pair off. They do much good on the stubbles by destroying various weed-seeds.

Other British species are the Mealy Redpoll (*A. linaria*), the Lesser Redpole (*A. rufescens*), the smallest British finch, and the Twite (*A. flavirostris*) with its longish tail, common in the north. This latter is sometimes very harmful to young cabbage and other crucifers in the north of Scotland. The mealy redpoll is almost confined to the north, but flocks sometimes appear as far south as the Channel.

The *Chaffinch* (*Fringilla cœlebs*).—This is one of our most beautiful finches, yet a veritable scourge to the gardener and even farmer. In the male the crown of the head and nape of the neck are French-grey, the rump green, the back chestnut and green, the breast reddish-pink, turning to white on the abdomen; the black wings have two pure white bands, and the tail is black in colour, except the two grey middle feathers, and a broad white band on the outer two. The female is ashy-brown and olive-green, the lower parts being paler and the bands less distinct than in the male. The chaffinch builds a beautiful compact nest of moss and lichen, often on lichen-covered trees, so much resembling the tree in appearance as to be distinguished with difficulty. Two broods are often produced in the year. In the winter they unite in flocks, the males and females separately, the males being most abundant in northern counties at this time of year, the females apparently going southwards. They feed upon all kinds of seeds, especially those of an oily nature. As soon as the garden seeds are in

—such as cabbage, turnip, beetroot, mustard and cress, and radishes—they soon go if the chaffinch finds them out. They also clear off the young shoots of plants and flowers, and even destroy germinating grain. On the other hand, they eat numbers of weed-seeds on the stubbles, especially the pernicious charlock, and feed their young on insects of various kinds, such as plant-lice, as well as devouring some themselves. On the whole, the chaffinch does as much good as harm, if we could only keep it away from our seeds — an almost impossible task.

The *Sparrows* (*Passer*). — There are two British sparrows, the House-Sparrow (*P. domesticus*) and the Tree-Sparrow (*P. montanus*). These two can be distinguished by the ear-region of the house-sparrow being bright grey, whilst that of the tree-sparrow is deep black; the former has also a reddish streak behind the eye, and the wings with one dusky white bar; the tree-sparrow has a black streak behind the eye and two white bands on the wings, and a white ring nearly round the throat; the head is a bright chestnut colour. The tree-sparrow is not abundant like *P. domesticus;* it is usually found in company with the latter. They are both very destructive at times. Corn, both in the seed and when in crop, is materially damaged by them, and there can be no doubt but that they are the cause of much loss in that respect to the farmer; but corn is not to be obtained all the year round, though they take it whenever possible in the farmyard, often eating as much as the poultry. At other times sparrows do some little good, for they devour many insect pests which we could never get at. The writer at one time condemned these birds before some farmers and gardeners in Surrey, when he was promptly brought to order by more than one, who pointed out their great benefit in destroying insects. Certainly they can be seen clearing off the "colliers" on beans, the green Dolphin on peas, and the "blight" on corn, and they feed ravenously on small larvæ on fruit-trees, such as the young Winter Moth and Tortrices. Water-cress growers say their chief remedy for the "caddis-worms" is to let the beds run dry, when the sparrows soon clear them off. Put to this the fact that they devour large quantities of weed-seeds, and then we may not think so ill of this cosmopolitan bird. We know not what might happen if we eradicated them—an almost impossible act to perform, as they are immensely prolific, having often three broods in the year. They are, however, far too abundant, and should be thinned out to some considerable extent. The young, like all finches, are fed entirely on insect food, and thus it is advisable not to destroy the nests, but to kill off the birds later in the year. Another great fault is that of waging war against the beneficial martins.

The *Goldfinch* (*Carduelis elegans*), although not nearly so common as formerly, is still met with all over Britain. Like all finches, the young are fed on insects; the adults live upon the seeds of thistles, knapweed, groundsel, and docks. Numbers come to these islands to breed in April, and leave again about October, migrating across the Channel.

The *Siskin* (*Chrysomitris spinus*) breeds in the central and north-eastern portions of Scotland, although a few nests are found every year in England. The young are fed mainly on plant-lice, while the adults devour great numbers of weed-seeds.

The *Greenfinch* (*Ligurinus chloris*) is often very destructive to seeds; but the young are fed upon caterpillars, and as they are very ravenous, there is no doubt but that the greenfinch does some good. The larvæ of the winter moth are taken in numbers by them, yet as a seed-destroyer in the garden this bird is most noxious. Its nest is built in hedges, in shrubs, in ivy, &c.,—a loose structure built of fibrous roots, moss, and grasses, with a lining of finer material and feathers. The first nest is built in April, and a second brood usually follows. Flocks of greenfinches may be seen on the stubbles in the autumn, where they not only feed off weed-seeds but also attack newly-sown wheat.

Buntings (*Emberizinæ*).

Of the eleven species of Buntings found in Great Britain, the Yellow-hammer (*Emberiza citrinella*), the Reed-bunting (*E. schœniculus*), and the Corn-bunting (*E. miliaria*) are the commonest.

The *Yellow-hammer* (*E. citrinella*) has its head, neck, breast, and lower parts generally yellow streaked with dusky-brown, the upper surface being reddish-brown. The female is not so yellow as the male. They may be found in all parts of Great Britain, building their slight nest of grasses and moss on or near the ground, in April and May. Both male and female help in incubation. Young and adults feed off insects in the summer, but in autumn fruits and seeds take the place of insects, and in winter corn as well. They unite in flocks in the winter, and may be seen in the fields busily engaged hunting for the weed-seeds, which they eat in large numbers. Such generally is the food of the Emberizinæ.

Finches, with the exception of the bullfinch, sparrow, and greenfinch, may be said to be more or less useful birds, on account of the numerous insects and weed-seeds that they destroy.

SWALLOWS AND MARTINS (HIRUNDINIDÆ).

These useful migrants have all long and pointed wings with nine primary feathers. The three species—the Swallow, House-martin, and Sand-martin—are placed in three separate genera. They have all a wide gape, with few hairs on the mouth; the feet are short, with three toes directed forwards, one behind. The tail is more or less forked.

The *Swallow* (*Hirundo rustica*) belongs to the genus Hirundo, in which the tail is strongly forked and consists of twelve feathers, the outermost ones being elongated to form the two tails; the legs and feet are bare. The swallow is only a summer visitor, arriving about the middle of April, and leaving again in the autumn. The nests, of clay and mud lined with fine grasses and feathers, are chiefly placed in sheds and chimneys and ledges of rock. They feed, both in young and adult stages, upon various insects taken on the wing, especially crane-flies (*Tipulæ*), moths, gnats, and beetles. Swallows unite in large flocks prior to migrating in the autumn. Two and even three broods are produced during their stay; sometimes the last brood does not develop in time to undertake the long migration. Whether these backward birds stay all the winter seems a disputed point. They may now and then be seen at Hastings in November, and twice I have observed them in December flying about on a warm day.

The *House-martin* (*Chelidon urbica*) has a forked tail, but it is not long like the swallow, and the legs are feathered above. This martin generally arrives a little later than the swallow, and leaves in October and November. A few have been seen in December. The nest, of mud, is placed under the eaves of houses, walls, and rocks; the nest is cup-shaped, with a hole at the top or side. They, like the swallow, feed entirely on insects. Sparrows wage war against them, and often drive numbers away from their nests.

The *Sand-martin* (*Cotile riparia*) often makes its appearance at the end of March, and commences to leave at the end of August and in September. The genus Cotile has a tuft of feathers only on the leg, just above the hallux. It nests in sandbanks, railway-cuttings, and sand-quarry faces, making a slanting tunnel· with a large chamber at the end. On the floor of this chamber are placed a few pieces of fine grass and feathers, where the bird lays from four to six pure-white eggs. Sand-martins breed in colonies, and are often attacked by sparrows, which they occasionally defeat when large colonies are invaded. Like the two preceding species, insects form the sole food.

WAGTAILS AND PIPITS (MOTACILLIDÆ).

The Motacillidæ contain two genera, the Wagtails (*Motacilla*) and the Pipits (*Anthus*). The bill is nearly straight, slightly notched at the tip, the mandibles nearly equal in length, and their edges slightly compressed inwards. In the Wagtails, the tail, which consists of twelve feathers, is long and the feathers nearly equal; in the Pipits the tail is only moderately long and slightly forked. The tarsus in the Wagtails is longer than the middle toe, but in the Pipits it is the same length. The Wagtails are partially migratory in habits. Five distinct species are now recognised in Great Britain. Of these the Pied Wagtail (*M. lugubris*) and the Yellow Wagtail (*M. raii*) are the most abundant; the other three are the Blue-headed Wagtail (*M. flava*), the Grey Wagtail (*M. melanope*), and the White Wagtail (*M. alba*).

The *Pied Wagtail* (*M. lugubris*) is a common bird throughout Britain. They move southwards in the autumn, large flocks leaving for the Continent in September and October. They return in March—the males, as a rule, first. The "dishwasher," as the pied wagtail is often called, frequents the banks of streams and ponds, where it runs about jerking its tail up and down, and feeding upon all manner of insects. They may often be seen following the plough, picking up with great dexterity the insects turned up in the soil. Some remain in the south all the year round. The nest is made in April, generally in a hole in a bank or the hollow of a tree or wall, and is composed of dry grass and dead leaves, lined with wool, hair, and feathers. From four to six greyish-white eggs speckled with brown are laid in it, and very often we find the cuckoo's egg in the nest. The plumage is variegated with black and white; back, chin, throat, and neck black, except a small part of the neck which is white; in winter the back is ashy-grey and the throat is white.

The *White Wagtail* (*M. alba*) is the Continental form of the above species, from which it may be told in the summer by its back being pearl-grey and the flanks grey instead of black. Its food and habits are identical with the above, but it is not so common.

The *Grey Wagtail* (*M. melanope*) can be told by its yellow tints. The head and back are grey, but the neck and breast are yellow, and the throat is black. We find this species in the south in winter; but in summer it goes north, to make room, as it were, for the other wagtails that migrate from the Continent. It is chiefly found by rapid streams and rivers in mountainous and hilly country in the north, only coming south in winter and during migration. It builds its nest in banks by the sides of streams and feeds upon aquatic insects.

The *Blue-headed Wagtail* (*M. flava*) is the Continental form of the grey wagtail, from which it can be told by the absence of the black on the throat. It is especially found in the south, south-west, and east of England. It seems to prefer flies, which it takes quite close to animals which attract them.

The *Yellow Wagtail* (*M. raii*) is one of our regular summer visitors, and is generally common. In colour this bird is yellow and olive; the head, nape, and back are pale olive; chin and lower parts yellow; a yellow streak is also present over the eyes. The neighbourhood of ponds, canals, and ditches seems its favourite locality; but they may also be seen near cattle, catching the flies attracted to them. All these birds are insect-feeders, and thus should be encouraged and their nests preserved.

The Pipits (*Anthus*) are insectivorous, but weed-seeds are also eaten by them.

THE SHRIKES (LANIIDÆ).

The Shrikes or Butcher Birds have a rather short compressed bill; the upper mandible hooked at the point, and with a prominent tooth. The base of the bill is beset with bristly feathers directed forward. Four species are found in Britain; the Red-backed Shrike (*Lanius collurio*) is the most abundant. This bird arrives in the early part of May, and leaves us again in August. The nest, which is large, is placed in a thorn hedge as a rule, some five or six feet from the ground. The food consists of lizards, mice, beetles, bees, and other insects. The food, especially the insects, are impaled on thorns around the nest, hence their common name "Butcher Bird." Three others are found in the summer, namely, the Great and Lesser Grey Shrikes (*L. excubitor* and *minor*), and the Woodchat (*L. pomeranus*). The Butcher Bird is looked upon as one of the farmer's friends; but if one examines the larder of these birds one finds as many beneficial and useful insects as injurious ones impaled upon the thorns.

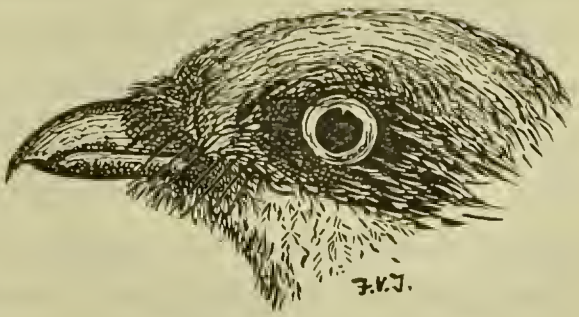


FIG. 228.—HEAD OF SHRIKE.
The Red-backed Shrike (*Lanius collurio*).
(Slightly enlarged.)

THE TITS (PARIDÆ).

This useful family of birds are often accredited with destroying fruit-buds. If we examine the buds being attacked by them, we shall find that they contain either some mite or maggot, and thus they are doing us inestimable good. They are all mainly insectivorous. The commonest species are the Great Tit (*Parus major*) and the Blue Tit (*P. cæruleus*). Both these birds peck the base of pears, and so do harm; but they may be kept from this in plantations by growing sunflowers, so that they seed the time the pears are ripening.

The Great Tit is more abundant in the south than the north. It is extremely vicious, and its strong beak makes it a formidable enemy. It is said that it attacks other small birds, and cracks their skull open to feed upon the brain. The chief food consists of insects of various kinds, especially small larvæ and pupæ. Like all the Paridæ, the great tit is an expert climber, hunting for grubs as it progresses up and round the tree-trunk and boughs. They make their nests in all manner of queer places, the nest being lined with fur, hair, and feathers, and contains as many as eight or nine small white eggs spotted and blotched with pale red. The head and throat are black, back olive-green, breast and abdomen yellow, a black line running down the breast; cheeks pure white.

The *Blue Tit* (*P. cœruleus*), sometimes called the Tomtit, is another useful bird. It builds its nest in holes in walls, trees, &c. The young are fed with small larvæ and plant-lice. The old birds hunt the orchards and clear off endless hibernating insects, such as codling moth larvæ, American blight, aphis, and red-spider eggs. Sometimes they damage buds, but it is nearly always for the enclosed mite. Most fruit-growers now encourage it for the good it does.

The other British species also feed on a similar diet, varied with nuts and seeds. Large numbers of blue tits seem to come from the Continent in autumn and help to clear our orchards of insect pests.

WARBLERS (SYLVIINÆ).

The Warblers, such as the Whitethroat (*Sylvia cinerea*), the Chiffchaff (*Phylloscopus rufus*), and many others, mainly migrants, are insectivorous in habits. Some feed upon fruits as well as insects; the Blackcap (*Sylvia atricapilla*), for instance, often does much harm to red-currants and raspberries, whilst abroad it attacks figs and oranges. The Garden Warbler (*S. hortensis*) also does some harm, feeding off peas and fruit; but its young are brought up on caterpillars, especially those of the noxious Pieridæ or Whites. Similar remarks apply to all the species, of which there are some twenty recorded in Great Britain. The young warblers differ but slightly from the adults in coloration. The Whitethroats do endless good in clearing off pea aphis, spruce chermes, &c.

THRUSHES, BLACKBIRDS, &c. (TURDINÆ).

The last sub-family of the Turdidæ contains the Thrushes and Blackbirds (*Turdus*), the Wheatears (*Saxicola*), the Robin (*Erithacus*), and the Nightingale (*Daulias*), &c. The young of the Turdinæ differ from the adults in plumage, always having the upper parts more or less spotted. The Turdinæ live upon insects, molluscs, seeds, and fruit.

The *Blackbird* (*Turdus merula*) need not be described, as it is too well known. It is a resident over the greater part of Britain. It is no unusual thing to get white and piebald specimens of the blackbird. The food is very varied: they destroy many insects, and are especially useful as snail and slug devourers; but they commit sad havoc with the fruit, notably gooseberries, in the summer, especially in dry weather; they peck the best apples and pears and ruin them, and as they have of recent years much increased they should be shot in fruit districts. The hen is dusky-brown with a spotted breast, whilst the beak is brown with yellow edges; the cock is deep black with a yellow bill. The curious habit it has of raising its tail whenever it perches will always enable the observer to detect it. It nests very early, in bushes, trees, and hedges: the nest is lined with fine grasses, in which are laid five greenish-blue eggs streaked and spotted with reddish-brown.

The *Thrush* (*T. musicus*) also feeds upon much the same food. This beautiful song-bird, the "throstle" of the north country, is found all over the islands. They often migrate in large numbers, this movement taking place at night. The nest, which may be made in February, is lined by a smooth coating of dung and mud, and in it are laid four or five blue eggs spotted with black or dark-brown. The food, although similar to the blackbird, is more varied. They do an immense amount of good in the garden by crushing and eating the snails, and by devouring hordes of slugs, wood-lice, insect-grubs, &c. The snails are smashed, as a rule, against a stone or tree and soon eaten; heaps of broken snail-shells may often be found lying about, the remains of a "throstle's" meal. They, however, do some harm to fruit, always taking the choicest kinds; but in ordinary numbers they cannot be otherwise than looked upon as gardeners' friends.

The *Fieldfare* (*T. pilaris*) and the *Redwing* (*T. iliacus*) are regular winter visitors, feeding upon insect-grubs and worms in the fields and woods, unless the ground is covered with snow, when berries are eaten.

The *Missel-Thrush* (*T. viscivorus*) is another permanent species, the largest of the genus. It breeds in our islands, and its numbers, like so many of our birds, are greatly augmented in winter by migrants. The "storm-cock," as it is sometimes called, makes its nest in the fork of a bough of a tree as early as February. In habits the missel-thrush is very vicious, often attacking other birds and carrying off the nestlings. The food consists of various wild berries, worms, snails, slugs, and insects.

The *Nightingale* (*Daulias luscinia*) is found in the southern, eastern, and midland counties of England. In the west it becomes rare, and is almost unknown in Devon and Cornwall. In Wales it is very rare, whilst it is quite unknown in Westmoreland, Cumberland, Northumberland, Durham, Scotland, and Ireland. This noted singing bird comes to us about the middle of April; but I have notes of its appearance in Sussex and Kent as early as April 3. It leaves us again in the autumn, either singly or in small flocks. Insects form the chief food; but fruit, berries, and worms are also devoured. The old birds migrate later in the year than the young.

The Turdinæ are mostly beneficial, although at times they rob us of our fruit, and, in the case of the blackbird, need keeping in check; but the vermin that they kill would do far more damage than they do. These birds have the most highly developed voice, and their general structure places them at the apex of bird organisation, the brain especially being well formed.

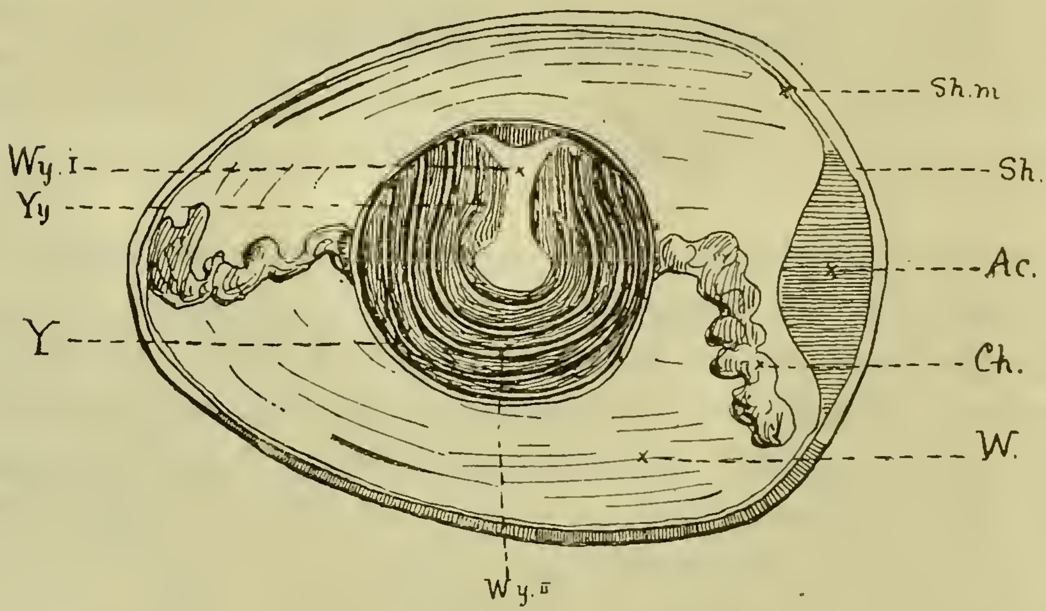
CHAPTER XVII.

EMBRYOLOGY OF THE CHICK.

THE EGG OF THE FOWL.

It is necessary that we should have a complete knowledge of the structure and formation of the hen's egg before we can consider the stages that take place within it during the development of the chick. To examine an egg we should be careful first to obtain a fresh one, and then compare it with one that has been kept some time. A fertile and an unfertile ovum should likewise be compared.

The external envelope is the *shell* (fig. 229, *Sh*), which is composed of two layers. The shell is impregnated with calcic salts; it is more or less porous, to allow the free interchange of gases, which are necessary for the respiration of the contained embryo during the process of incubation. The shell may become coloured with pigment, both layers of it sometimes containing colouring matter. Lining the shell are two thin skins, the shell-membranes (*Sh.m*), the outermost layer being much the thicker of the two. In a fresh egg these two shell-membranes are closely approximated together, but can easily be separated at the broad end of the egg. Every day the egg is kept the farther these two membranes separate at the broad end of the shell, forming in eggs that have been kept some time a cavity called the *air-chamber* (*Ac*). This air-chamber gradually increases in size as the white of the egg becomes smaller by the evaporation of its water. Beneath the inner shell-membrane is the *white* or albumen (*W*) of the egg. This white is a mixture of proteids, fats, extractives, and saline matters. In this layer again we can distinguish between a fresh and a stale egg: in a stale egg the outer albumen is always more or less soft and watery, whereas in a fresh egg it is quite firm. This white contains no less than 86 per cent of water. The yolk lies within the white, and is enclosed in a thin membrane called the *vitelline membrane*, which is partly elastic in nature, and easily seen puckered up when we break the yolk of an egg.



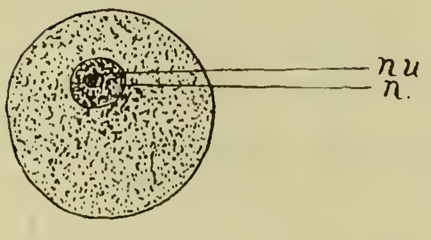


FIG. 229.—OVUM AND STRUCTURE OF A FOWL'S EGG

n, Nucleus; *nu*, nucleolus; *Sh.* shell; *Sh.m*, shell membranes; *Ac*, air chamber; *W*, white (albumen); *Y*, yolk; *Yy*, yellow yolk; *Wy.* i, white yolk of flask; *Wy.* ii, other layers of white yolk; *Ch*, chalaza. (Modified after Allen Thomson.)

The *yolk* (*Y*) itself is of two kinds, yellow and white; it, however, mainly appears yellow in colour, except at one place where a small round pale area exists, about the sixth of an inch across, the so-called *blastoderm*. The yellow yolk is surrounded externally by a thin layer of white yolk which passes under the blastoderm, where it extends into the middle of the egg, forming a flask-shaped central white mass of yolk (*Wy.* i). It is this part that remains soft in a hard-boiled egg. Between the outer thin layer of white yolk and the central flask-shaped mass are several other thin concentric layers of a pale hue (*Wy.* ii), so that the yolk of an egg really consists of alternate thin white and thick yellow strata. Between the yolk and the shell-membranes at each pole of the egg is a twisted cord—the *chalaza* (*Ch*). These two chalazæ do not quite touch the membranes, but spread out to a slight extent over the vitelline membrane. They act as buffers which help to keep the yolk in its place.

The *blastoderm* varies according as to whether the egg is unfecundated or fertile. In an unfecundated egg this "spot" is whitish in colour and more or less uniform all over; there may be very irregular clear spaces in it. In a fertile egg we shall see an opaque rim called the *area opaca;* internal to this a clear space, the *area pellucida.* In the middle of the latter area is a central white body, formed by the upper neck of the flask-shaped central white showing through. This blastoderm is composed of two layers; the upper consists of a single row of cells, the lower of a larger number more irregularly disposed.

THE ORIGIN AND FORMATION OF THE EGG.

As previously pointed out, the left ovary only is found normally in birds, situated on the left side of the backbone and against the dorsal wall. The appearance of the ovary varies a great deal with age. All we need consider here is the active adult state in which it is found when the hen is laying. At this period the ovary consists of a number of various-sized vascular capsules, in each of which is a primitive ovum (fig. 214). The smallest or youngest ova are simple cells. Each ovum contains a nucleus (fig 229, *n*), otherwise the "germinal vesicle"; in this latter is the nucleolus (*nu*) or germinal spot The most recently formed ova are naked cells, and about 1 mm. in size. A little later each ovum is enclosed in two membranes—the inner a radiately striated membrane called the *zona radiata;* the outer one lying between the zona and the epithelial layer surrounding the ovum, the vitelline membrane. The zona disappears, and leaves the ovum surrounded by the vitelline membrane alone. The largest of the capsules then contains a roundish yellow yolk-like body enclosed in a thin membrane—the ovarian ovum. Upon this body will be observed a small disc, the *germinal disc,* which consists of a globular body, the *germinal vesicle,* embedded in a mass of protoplasm. This yolk mass is then the true ovum, and this alone. When quite ripe it is dehisced from the *ovary* and passed into the funnel-like head of the oviduct. The reader must again be referred back to p. 339, where the structure of the oviduct is pointed out. It is in this oviduct that the white, shell, &c., of the egg is formed, by secretions from its glandular walls. In the second part of the tube, the oviduct proper, the albumen is deposited, and then the chalazæ and the albuminous layers completed. At the lowest end of this second division the shell-membrane is produced. It is said that the egg remains in the oviduct proper about three hours. The shell is formed by the walls of the third portion of the oviduct, the uterine portion. From the glandular walls of this uterine tube there is poured out a thick white covering to the egg, in which the inorganic matter is deposited. It takes normally from fifteen to twenty hours to traverse this part of the egg-tube. On leaving it the egg is rapidly passed out of the cloaca by the muscular contractions of the uterus, &c. Thus by knowing the structure and function of the various parts of the oviduct, we can tell what portion is diseased when we find parts of the egg ill-formed, such as absence of white or a thin shell.

The egg is fertilised in the first part of the oviduct, where the spermatozoa may be found freely moving about in the fluid contents of that cavity. After the egg is fertilised, and the various phenomena directly following impregnation have taken place, the germinal area of the egg commences to undergo the process known as *segmentation.* The bird's egg commences to segment soon after the eggshell is formed. The germinal area, which is a single cell in the ovarian ovum, at first divides into two by means of a furrow running across the germinal disc; this is shortly followed by another furrow at right angles to it, but not quite symmetrically. Then each of these quadrants becomes cut up by radiating furrows, and each is cut across again in the centre by a cross-furrow, so that the central cells are smaller than the outer ones. This cell-division goes on rapidly, always with greater rapidity towards the centre of the disc. Eventually the whole disc becomes more or less equally divided into a number of small cells, not only from above downwards, but horizontally also. The disc now becomes the *blastoderm*, in which we can distinguish two layers. The cells of the upper layer are closely applied, small, columnar, and with distinct nuclei, and form a definite membrane. The lower masses are composed of larger cells somewhat rounded and irregularly disposed. This stage may be seen on taking a section of the disc in an egg soon after it is laid.

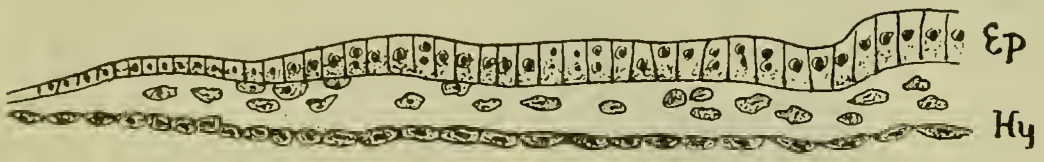


FIG 230.—SECTION THROUGH PART OF BLASTODERM (first day of incubation). *Ep*, Epiblast; *Hy*, hypoblast.

From this two-layered blastoderm the bird is built up during the twenty odd days of incubation. Only the *area pellucida* takes place in the formation of the embryo; the *area opaca* gives rise to various appendages of the embryo, which all eventually disappear. The blastoderm, as mentioned above, consists of two layers: the upper layer becomes the *epiblast* (fig. 230, *Ep*), and the lower the *hypoblast* (*Hy*). Between these two a third is formed, the *mesoblast.* These three germinal layers are present in all animals. From the epiblast arises the epidermis, the central nervous system, and sense-organs; the mesoblast gives rise to the vascular, muscular, skeletal, and connective tissues, excretory organs, and the generative glands. The lowest layer forms the lining of the alimentary canal (except near the mouth and anus, which are lined by epiblast) and the glands attached to the alimentary canal.

The blastoderm gradually grows round the yolk, and forms a sac round it by the seventh day of incubation. The *area opaca* is the part that covers the yolk, not the *area pellucida.* Whilst this extension of the blastoderm is going on, the embryo chick becomes formed by a folding-off of the central part of the *area pellucida.* At first there appears a semilunar groove, which, as it were, tucks in a small part of the blastoderm in the form of a crescent—the *head-fold.* Some time after the formation of the head-fold there appears a similar, but smaller, fold at the opposite end of the disc—the *tail-fold*—which travels forwards whilst the head-fold passes backwards. Between these two folds two lateral folds appear; these sink inwards, whilst the head-fold passes backward and the tail-fold forwards, tending to join in the middle line, and thus give rise to a small sac above, connected by a continually narrowing neck with a larger sac below. The upper is the "embryonic sac," the lower the yolk-sac; as the former grows the latter disappears. The yolk-sac is gradually absorbed for nourishment by the embryo chick being formed in the sac above. Within one or two days of hatching we shall see this yolk-sac disappear into the chick. The embryo thus folded off from the yolk-sac gradually thickens, and throws out various processes, swellings, &c., to form the legs, wings, and other parts by unequal growth. Internally more complicated changes go on. On the upper surface is seen a streak, the primitive streak, in which appears a depression, the primitive groove. In front of the primitive groove there is formed a thickening of the epiblast, the medullary plate, the sides of which, the medullary folds (*mf*), grow up and meet, forming a tube, the neural tube, the future cerebro-spinal canal (fig. 232, *Hb*). Below this, during the first day, appears previously a rod of cells, the future notochord (*Not*).

The blastoderm early in development becomes thickened by the growth of the mesoblast (*Mes*). The mesoblast on each side then *cleaves* into two layers. The upper part of the mesoblast unites with the epiblast to form an outer layer, the lower with the hypoblast to form a lower and inner layer. These two layers, known respectively as the upper, outer, or *somatopleure*, and the lower, inner, or *splanchnopleure*, grow down and meet to form two tubes. The inner tube, lined by hypoblast, is the alimentary canal, which in time becomes perforated at each end by two infoldings of the epiblast, forming the mouth and anus. The outer tube forms the tube of the body, the space between these two tubes being the body cavity. The embryonic sac is connected with the yolk-sac by a gradually narrowing hollow stalk. This stalk, like the embryonic sac, is double, there being a somatic and a splanchnic tube: the splanchnic tube connects the alimentary canal with the cavity of the yolk-sac; the somatic stalk connects the body walls of the embryo with the somatopleure of the yolk-sac. Very soon in development the splanchnic canal becomes obliterated, and thus shuts off the yolk from entering the alimentary tube. The

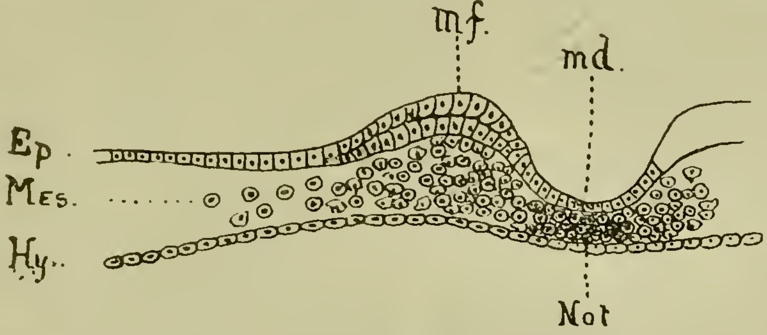


Fig. 231.—Transverse Section of Blastoderm, incubated for eighteen hours. (After Foster and Balfour.)

Ep, Epiblast; *Mes*, mesoblast; *Hy*, hypoblast; *md*, medullary groove; *mf*, medullary fold; *Not*, notochord.

yolk then finds its way into the body of the chick by means of absorption through the small blood-vessels. When the period of incubation is nearly complete the yolk-sac, which has gradually dwindled away, owing to the absorption of its contents, is withdrawn with its splanchnic membrane into the abdomen of the chick, and the walls of the abdomen close over it, leaving the somatic layer to shrivel up and disappear.

Another embryonic membrane of great import arising with the two layers referred to above is the *amnion* (*vide* fig. 235). The amnion is a membrane which arises from the somatopleure by a series of folds, and which envelops the embryo completely. Beneath these folds, which constitute the amnion, lies the embryo in a cavity filled with liquid—the amniotic cavity (*AC*). Each fold is composed of two layers, and when they meet above the embryo, the inner limbs go to form an inner layer and the outer a similar outer sac. The inner sac is the *amnion proper*, and contains the amniotic fluid. The outer sac lies close to the vitelline membrane of the yolk, while its peripheral borders extend, as the somatopleuric layer mentioned before, over the yolk-sac. This outer sac is the *false amnion* or *serous membrane*, and must not be confounded with the true amnion.

Lastly, we find an embryonic investment formed as a diverticulum from the alimentary canal. This fœtal membrane is the *allantois* (*al*), forming a projecting sac in the pleuroperitoneal cavity, which grows up between the true and false amniotic sacs. The allantois then becomes full of blood-vessels, and overlies the developing embryo, assuming a respiratory function.

Such, briefly, are the general structures of the embryo and its membranes at an early period of development. We shall now trace some of the more important changes and growths that appear from day to day during the incubation of the egg.

Changes during the first day.—During the first day of incubation the third or mesoblastic layer appears (*Mes*, fig. 231). This mesoblast originates as two masses from the hypoblast, and the notochord referred to below arises in a similar way and at the same time. Before the end of the twelfth hour a streak appears at one end of the *area pellucida*, the *primitive streak*, which is due to the thickening of the middle portion of the blastoderm by rapid cell-division of the epiblast. About this time the germinal area alters in appearance, the *area pellucida* becoming oval, and then about the fifteenth hour pear-shaped, and the primitive streak becomes the primitive groove by a lateral fold arising on each side. Between the seventeenth and twentieth hours there appears an axial opaque line below the primitive streak; this is the notochord (*Not*), which is composed of a number of concentrated cells. There then appears a groove in front of the primitive streak, the *medullary groove* (*md*), in a thickened epiblastic plate, which gives rise to the central nervous system; this is plainly seen about the twentieth hour. At the same time there will be noticed a fold in front of the head-fold that is commencing to appear; this is the *amnion*. From now to the end of the first day development proceeds rapidly. The head is definitely commencing to form. In front the medullary folds unite in the region of the future brain, forming a canal, the *neural canal*. The mesoblast on each side of the notochord beneath the medullary folds becomes cut up into a number of cubical plates; these are called *mesoblastic somites*, from which the voluntary muscles of the trunk and vertebræ are formed. The embryo now grows rapidly, and the primitive streak grows backwards. Similarly changes have taken place in the *area opaca* during the first twenty-four hours. The *area opaca* has spread out over the yolk and reaches the size of a sixpence, and that portion of it nearest the *area pellucida* can be told by its mottled appearance; this will become the vascular area of the embryo.

Changes during the second day.—During the second day the embryo presents very marked changes. The head end becomes prominent. The medullary folds in the cephalic region are quite closed. In front the neural tube has become swollen, forming the *first cerebral vesicle*, and from each side of this vesicle, by the rapid proliferation of the epiblastic cells, two processes grow out—the *optic vesicles.* A second and third vesicle then appear behind the first, and behind the third vesicle two pits, the *auditory pits*, the future organs of hearing. During the first half of the second day the *heart* (*Ht*) appears in the head-fold, its origin being connected with that cleavage of the mesoblast already referred to. It is formed in the pleuro-peritoneal space shown in fig. 232, and situated just beneath the developing fore-gut (*al*). At first the heart is flask-shaped, with a swelling at its anterior end and another behind, the future auricles. The heart is formed entirely from mesoblast, on the ventral side of the throat, by a curious process of hollowing out of the splanchnic mesoblast: some of the original central cells become blood-corpuscles. Concomitant with the appearance of the heart is the vascular system, which consists of a number of tubes hollowed out in the mesoblast. Blood-corpuscles are rapidly formed in masses in the vascular area, called *blood-islands.* By degrees the heart becomes S-shaped, the right-hand curve of

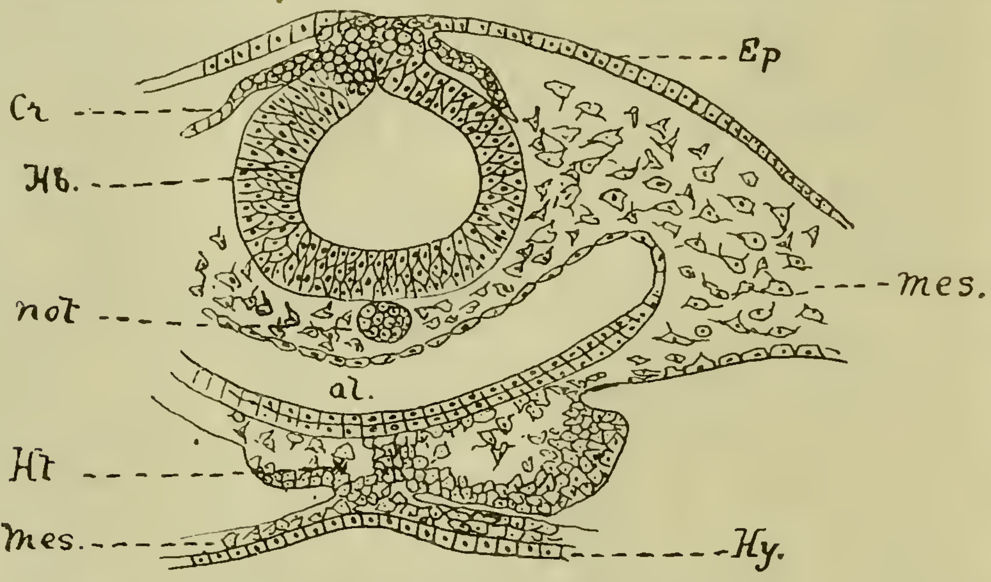


FIG. 232—TRANSVERSE SECTION THROUGH POSTERIOR PART OF THE HEAD OF AN EMBRYO CHICK OF THIRTY HOURS.

Hb, Hind-brain; *Cr*, vagus nerve; *Ep*, epiblast; *not*, notochord; *mes*, mesoblast; *al*, throat; *Ht*, heart; *Hy*, hypoblast. (After Foster and Balfour.)

the S being venous and the left-hand curve arterial. The venous bend has two bulges, the future auricles, the ventricles appearing at the other bend. The first true circulation of the blood takes place during the close of the second day. The heart at this stage gives rise to *two aortæ;* these later unite into one trunk behind the head, and towards the tail this trunk gives rise to two *vitelline arteries*, which run to and are lost in the vascular area. Here two veins arise from the capillary network, the vitelline veins, which run back to the heart. In this stage we may find two, or even three, pairs of aortic arches. The whole embryo is raised up from the blastoderm, and the head end becomes bent. In the region of the middle somites there appears a small mass of cells seen in a transverse section; this is a ridge, the primitive excretory or *Wolffian duct*, which becomes hollow, and connected with the embryonic excretory organs, the Wolffian bodies.

Changes during the third day.—One of the most noticeable things in an egg on the third day of incubation is the disappearance of much of the white, which has been absorbed directly by the blood-vessels and indirectly by the diminishing yolk. The vascular area has much increased, and not only now supplies the embryo with food from the yolk, but by virtue of its external position (lying against the shell) it takes part in the respiration of the embryo. The amnion forms a complete investing membrane, and the whole embryo comes to lie on its left side. The head region also becomes much bent under, forming the cranial flexure, the second brain vesicle now being in front, the first bent below. On examining a section through the brain region we shall see that there appears a process on each side of the summit of the brain: these lateral processes are the origin of the cranial nerves (fig. 232, *Cr*). They are formed as paired outgrowths, which afterwards shift their attachment to the floor of the brain. Similarly the spinal nerves now arise and become divided into three parts—a root, a ganglion, and the distal nerve. At this period the eyes are formed by the optic vesicles becoming folded in, in front, producing a cup-shaped depression, and the optic stalk becomes small and converted into the optic nerve. From this cup-shaped vesicle the various parts of the eye arise. The epiblast over the vesicles becomes thickened and folded into them; the mouth of the vesicle is closed, and the whole part pushed in breaks off and forms the lens. The mesoblast round the optic vesicles gives rise to the choroid and sclerotic, whilst in front the mesoblast grows over the lens and forms the cornea, the epiblast over it simply forming the epithelial covering. The organs of hearing and smell also arise as epiblastic invaginations, the former showing on the second day, the latter only on the third.

In the neck region appear those curious structures found in all vertebrates, the *visceral clefts.* The visceral clefts are fissures that pass through the walls of the throat to the pharynx. There are four on each side, and they are formed by a pushing out of the internal hypoblast and a pushing in of the external epiblast until a perforation is made. On the anterior border of each cleft is a thick fold, the *visceral fold* (fig. 233, *F* 1 to *F* 3), the fourth cleft having two folds. These visceral clefts are remnants of pre-existing gill-slits. The first pair of folds only remain in a modified form, taking part in the formation of the mouth and mandibles. They each send off a branch during the third day to the anterior edge; these two branches nearly meet, but are separated by a median process. Between the main folds a space appears; this becomes the mouth (*M*). The second and third arches partly remain as the hyoid bones, the last two becoming quite obliterated. The first visceral cleft persists, being connected with the auditory organ, becoming the Eustachian tube and tympanic cavity.

The three parts of the alimentary canal on the third day unite. From the œsophagus the lungs arise as bud-like outgrowths. Liver and pancreas also make their appearance by a similar process, both the latter arising between the fifty-fifth and sixtieth hours of incubation—the liver as two diverticula from the duodenum, and the pancreas as one solid outgrowth slightly behind the liver. From the somites now arise the muscle-plates, and the Wolffian bodies or primitive kidneys become fully developed.

Changes during the fourth day.—A still further diminution of white is seen; the embryo, which has very much grown, lies close to the shell-membrane. More than half the yolk is now

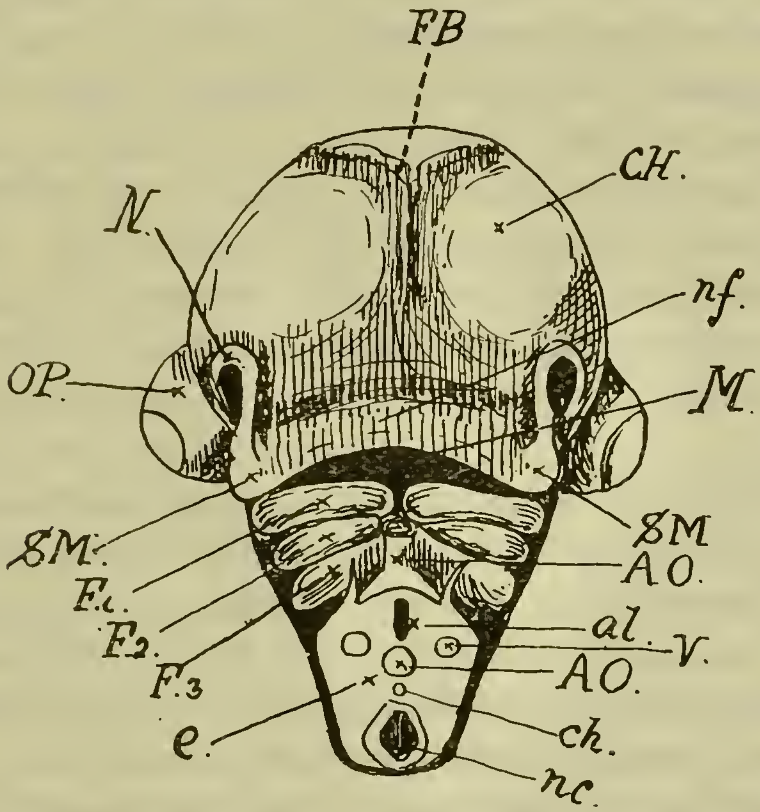


Fig. 233.—Head of Embryo Chick of the Fourth Day.

CH, Cerebral hemispheres; *FB*, vesicle of the third ventricle; *OP*, eyeball; *nf*, naso-frontal process; *M*, cavity of mouth; *SM*, superior maxillary process of *F*. 1, the first visceral fold; *F*. 2 and 3, second and third visceral folds; *N*, nasal pits; *e*, neck between third and fourth visceral folds cut across; *al*, alimentary canal; *V*, jugular veins; *AO*, dorsal aorta; *nc*, neural canal; *ch*, notochord. (After Foster and Balfour.)

invested by the germinal membrane, and the blood-area is about an inch in diameter. The amnion obscures the view of the chick, which lies beneath it. Both cranial flexure and tail-fold have much increased, and thus the embryo appears spirally coiled. On each side of the chick is now seen a long ridge—the Wolffian ridge; on this there appear two anterior and two posterior bud-like outgrowths, *the limbs*. The anterior buds or wings arise near the heart, the legs near the tail. The eyeballs (fig. 233, *OP*) project to a large extent, and the primitive skull begins to form in the mesoblast surrounding the brain. The true vertebræ arise from the old somites by a fresh segmentation, which does not follow that of the old segmentation of the muscle-plates. Each vertebra is formed of parts of two somites. The vertebral column now becomes supported by cartilage, and the notochord vacuolated and eventually squeezed out by subsequent ossification. Between the eightieth and hundredth hours the permanent kidneys appear. The tube of the kidney appears first as a diverticulum from the Wolffian duct. The kidney arises from a mass of mesoblastic cells closely applied to the Wolffian body, but this mass soon breaks off from the former. From the ureters there eventually grow out a number of tubules which become continuous with the cells of the metanephros and become the true kidney tubules. The kidneys are complete by the seventh day. Lastly, during the fourth day the generative organs develop; but at this time it is impossible to tell the sex, for the first-formed cells, the primitive cells, are the same in both male and female. The duct of the ovary, of which only one, the right, as a rule, remains, is formed from the Müllerian duct, that of the testes from the Wolffian ducts. The allantois now receives two branches from the dorsal aorta; these *umbilical* arteries become very important towards the close of this day. The first aortic arch, which runs in the first visceral fold, degenerates, and a new one appears as the fourth arch. The second pair also nearly disappear, and then a fifth pair come as the fifth arch. We thus still get three pairs of aortic arches, but placed farther back. Part of each remains to form the internal and external carotids. The hepatic circulation also becomes complete, and the mesenteric veins of the alimentary canal appear, and the septum of the ventricles now shuts off the right and left half of that chamber.

Changes during the fifth day.—The whole yolk is now enclosed in the blastoderm and about two-thirds covered by the vascular area. The allantois forms a large vascular patch on the right side, and the embryo is so curved that head and tail nearly meet. The limbs have greatly increased and become bent to form the elbow and knee, and the parts to become bone are invaded by cartilage. Cartilaginous bars also arise in the body walls, the ribs: some of the ventral parts of the ribs unite and form a cartilaginous sternum. The bones of the skull also arise, and cartilaginous rods in the visceral arches. The face undergoes great alterations, including the closing in of the nasal passages by nasal processes. Great changes also appear in the heart: the ventricles become pointed, and the auricular septum begins to show, the cavity of the auricles separating from the ventricles. The ventricles do not completely divide until after the thirteenth day of incubation. It is not until this day that the cells of the chick become properly differentiated, and from now they rapidly vary in each part, forming the various definite tissues that build up the body.

Changes during the sixth and seventh days.—On these days the embryo becomes distinctly marked with avian features. On opening the egg we shall note that the body is not so flexed, and also that the neck of the bird is more prominent. Still we may observe the heart hanging out of the body; but it commences to become enclosed by the thoracic walls, supported by the developing cartilaginous ribs. The cerebral hemispheres are quite large. By the seventh day we can see no traces of the visceral clefts, and the mouth and face assume avian characters. The amniotic cavity is quite large on the sixth day, being filled with liquor amnii, and gradually increases; and on the seventh day this amnion moves in a rhythmical manner: by this pulsating movement the embryo is rocked to and fro in the egg.

From the eighth day onwards.—During the eighth, ninth, and tenth days of incubation rapid growth takes place. The allantois is spread out as a sac over most of the yolk and serves as the chief organ of respiration, and the yolk-sac rapidly decreases in size. About the eleventh day one can tell to what group the embryo belongs, generic characters being often plainly marked. Feathers begin to appear as papillæ on the ninth day along the back and rump. These feathers remain in sacs until the nineteenth and twentieth days, but their colour shines through the sac. A chalky knob appears on the nose on the ninth day, and by the twelfth this has become converted into a soft beak. The cartilaginous skeleton is fully formed by the thirteenth day, so are most of the important muscles; and on the twelfth day many areas of ossification may be seen in the limbs, ribs, head, &c.

The loops of the intestines become confined in the abdomen on the eleventh day. The body still is connected by the narrow somatic umbilicus, the allantoic stalk, and suspensory cord of the yolk-sac with the accessory appendages. The whole embryo is now surrounded by the allantois, which is closely applied to the serous membrane against the shell. About the sixteenth day all the white has gone, and the mesoblast is cleaved right round the yolk. On the nineteenth day the yolk-sac is withdrawn through the somatic stalk into the abdominal cavity. The embryo is now surrounded by the vascular allantois, the serous membrane, and the amnion. The amnion is continuous at the umbilicus with the walls of the embryo, whilst the serous membrane is entirely separated from it. The allantois is continuous with the cloaca, by means of its stalk passing through the umbilicus.

On the fourteenth day the chick lies with its beak touching the serous membrane and shell membrane, where they form the inner wall of the air-chamber. On the twentieth day the chick pushes its beak into this chamber and breathes air. At this time the pulmonary circulation comes into play, and the flow up the umbilical vessel ceases. The allantois shrivels up, the umbilicus closes completely, and the chick pecks its way out of the shell, leaving behind the allantois, amnion, and serous membrane.

This incubation normally lasts twenty-one days, but it is not at all unusual for it to be prolonged to twenty-five days. The writer has had fowls hatch off even at thirty days, when the eggs given the hen had been laid some time previously. This is especially noticeable in Indian game. It seems that the longer the egg has been laid the longer the period of incubation, within certain limits.

CHAPTER XVIII.

MAMMALIA.

The Mammals are all warm-blooded animals, have their skin more or less covered with hair at some period of their life, and produce their young alive (except *Monotremes*). The young are always nourished for some time after birth by a specially prepared fluid—milk—which is secreted by the *milk-glands* or mammæ. These glands vary in number in different mammals, and are situated on the thorax or abdomen, or on both regions at the same time. The embryo mammal is always enveloped in an amnion and allantois (fig. 235, *am, al*). The latter may disappear, or it may remain, partly forming the *placenta*, a vascular structure that connects the fœtus with the parent. Contrary to what we saw in birds, the skull of a mammal (*vide* Anatomy of the Horse) articulates with the vertebral column by *two* condyles, attached to the occipital bone. Other features in the mammalian skeleton by which we can isolate them from the Sauropsida are, first, that the lower jaw articulates with the skull by the squamosal bone direct, and is never united to the quadrate bone. Secondly, the lower jaw consists of two halves or rami, and each ramus of a single bone only, not several as in Birds and Reptiles. A complete separation exists between the thoracic cavity and the abdomen, the dividing membrane or diaphragm being in the form of a thin musculo-tendinous partition. The heart consists of four chambers, the right and left sides being separate. The red blood-corpuscles are non-nucleated; one aorta alone exists—namely, the left—which turns over the left bronchus, not the right as in the bird. Lastly, the Mammalia never have those curious respiratory prolongations, the air-sacs, so characteristic of the Class Aves. Although there are marked differences between the sauropsids and mammals, yet we have intermediate and connecting links in the peculiar Monotremes of Australasia.

We need not refer further to the anatomical features of the Mammalia: the reader is referred to the chapter on the Anatomy of the Horse for fuller details, whilst the peculiarities of each group will be pointed out as we proceed.

DEVELOPMENT OF A MAMMAL AND THE FŒTAL MEMBRANES.

Mammals, unlike birds, possess two ovaries, as described in chapter xii. In the early stages there is much resemblance between the ova of a bird and a mammal. There are many very important differences, however, later. The Bird's egg is large and full of yolk; the Mammal's is small, and has a scanty supply of yolk. The embryo bird can live and grow on the food stored in the egg, but the fœtal mammal has to depend on maternal food derived from the parent's blood by means of the structure called the placenta, and later from the milk. There are two periods of mammalian development: (i) uterine development, (ii) post-uterine development. The first is the more important. Mammals produce viviparously, birds oviparously. The primitive ova are budded off from the epithelium covering the ovary. In the solid part of the gland—the stroma—are vesicles of all sizes, the Graafian follicles. Each follicle has a wall of its own, and contains one ovum (rarely two). The epithelium of the follicle forms two layers, an external one, the *membrana granulosa*, and another mass projecting into the vesicle and surrounding the ovum — the *discus proligerus*; the cavity of the Graafian follicle is full of liquid. As these follicles become ripe they project from the ovary, burst, and release the contained ovum and a quantity of the liquid which surrounds it.

The ovum is a spheroidal cell about $\frac{1}{125}$ to $\frac{1}{500}$ of an inch in diameter, and is surrounded by two membranes—the outer, the *zona radiata*, and an inner thin membrane. Within this thin membrane, shown to exist by E. v. Beneden, is the *vitellus* or yolk, filled with fatty and albuminous granules. In this vitellus is the germinal vesicle (nucleus), with one or two nucleoli. The ova burst from the ovary, when the latter is clasped by the funnel-shaped end of the oviduct. They then pass down the tube, being fertilised in its upper extremity by the entering of a single spermatozoon, and soon commence to undergo the process of segmentation. Segmentation is complete, the whole ovum being affected. This is spoken of as complete or *holoblastic segmentation.* The bird's egg only undergoes partial or *meroblastic segmentation*, owing to the quantity of yolk in the ovum. Segmentation lasts seventy-two hours in the rabbit, according to Balfour — this stage varying in different animals to a considerable extent. When complete the ovum consists of an outer layer of cubical cells surrounding an inner layer of granular polygonal cells, except at one spot where the inner granular cells are exposed, the so-called *blastopore* (fig. 234, *Bl*). When segmented the ovum passes into the uterus and becomes attached to it. Here the blastopore closes up. The vesicle then produced is formed by a cleavage between the outer and inner layers, which gradually increases until the inner granular mass is only to be seen at the point of the now closed blastopore (*Hy* 2). During this change the ovum enlarges rapidly, so that there is formed an extensive cavity in it, the inner granular mass now only forming a small patch against the outer layer at one spot. This cavity is the *blastodermic vesicle* (*Bl.v*). Surrounding it is the *zona radiata* and an albuminous layer (*Alb.E*). As the vesicle grows the inner mass of cells spreads out and forms an irregular layer beneath, except at its original position, in which it remains thick. This thick mass of granular cells we call the embryonic or germinal area. During the following few days changes take place in the inner layer. About five days after impregnation the cells of the embryonic area divide into two layers, the lower composed of flattened cells, and forms the hypoblast. During the subsequent day a middle layer arises and fuses with the epiblast to produce the true epiblastic layer. These two layers form a circular embryonic patch on the ovum, which on the seventh day becomes oval. There appears at the lower part of this spot a primitive streak as in the fowl. The area then becomes pyriform, and the primitive streak is marked by a groove. The epiblastic cells which form the streak also give rise to part of the mesoblast.

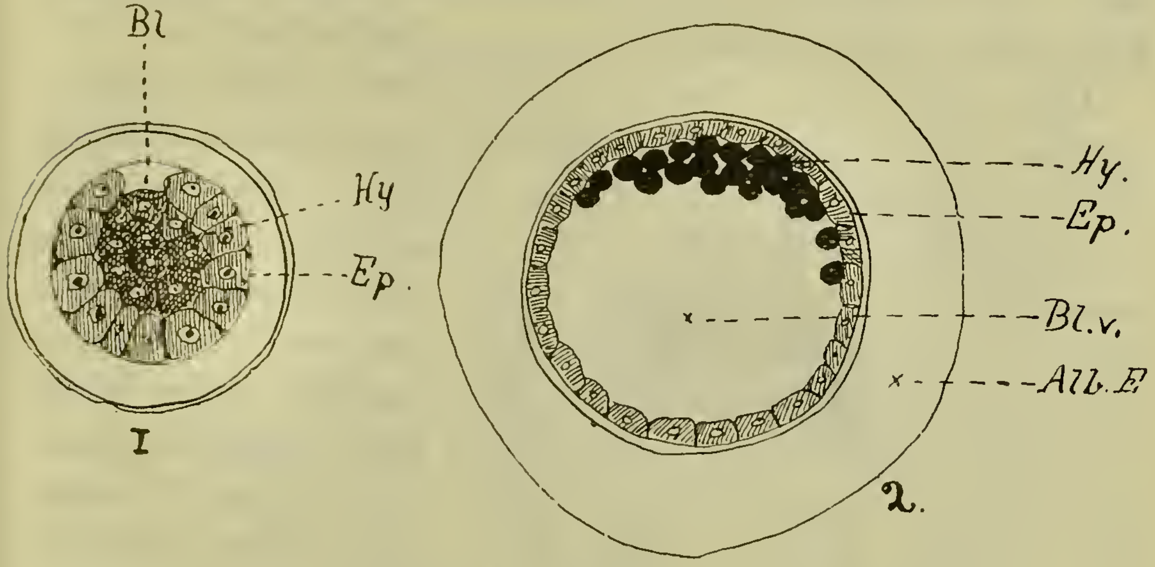


FIG. 234.—OVUM OF RABBIT.

1, Optical section of a rabbit's ovum at a stage closely following segmentation: *Bl*, blastopore; *Hy*, inner layer; *Ep*, outer layer. 2, Rabbit's ovum between 70-90 hours after impregnation: *Bl.v*, cavity of blastodermic vesicle (yolk-sac); *Ep*, outer layer; *Hy*, inner layer; *Alb.E*, albuminous envelope. (After E van Beneden.)

Very similarly to what we saw in the development of the chick the medullary groove arises in front of the primitive streak. The medullary plate between the two medullary folds is composed of one row of epiblastic cells, only, at first. The mesoblast arises from a double origin—(1) from the epiblast and (2) from the hypoblast. The notochord arises as a thickened axial portion of hypoblast. The area in which these three layers arise is the embryonic area, and here alone the fœtus is formed. The other part of the egg forms the *umbilical vesicle* (fig. 235, *UV*), which folds off from the embryo and may be likened to the yolk-sac of the fowl's egg. But in this sac we do not find yolk but a fluid that readily coagulates. The umbilical vesicle becomes surrounded by hypoblast, just as the yolk-sac of the bird became encircled by it.

About eight days after impregnation there may be seen a splitting of the lateral mesoblast into a vertebral and peripheral zone, and in the former two somites appear. At the ninth day a clear ring is seen around the embryo, and outside this an *area vasculosa.* The medullary plate swells into a cephalic enlargement. On each side of the head is to be seen a long tube. These two tubes are the commencement of part of the heart. Later the trunk of the embryo grows faster than the head, and the head becomes folded off, and a little later the tail-fold appears. The medullary groove remains open for some time, and forms the fore-brain, mid-brain, hind-brain, and optic vesicles by a series of enlargements. At the close of the ninth day the medullary groove becomes closed and the head is quite free, the two halves of the heart coming together and forming a median single tube. The somites also increase to about twelve. During these changes the amnion (fig, 235, *am*) has nearly encircled the fœtus, and the allantois (*al*) has commenced to grow as in birds. Later development consists of the well-marked cranial flexure and the presence of three visceral arches. The first forms the posterior border of the mouth, and sends forward a process on each side which forms the anterior margin of the mouth. Although there are only three arches, there are nevertheless four visceral clefts. The whole embryo becomes very much bent, the limbs appearing as buds in the same way as in the chick.

The *fœtal membranes* in mammals differ much from those of birds, except in the early stages. Mammalian fœti are closely attached to the parent by means of a membrane called the *placenta*, which more or less closely unites the fœtus to the walls of the uterus in which it develops (fig. 237). The placenta is formed by the allantois, the walls of the uterus, and the false amnion. The embryo mammal becomes folded off in a sac, the embryonic sac, just as does the chick, from the yolk-sac, called in the Mammalia the *umbilical vesicle* (*UV*). The *amnion* grows up on each side and unites above the embryo. The inner fold or true amnion then separates from the outer or false amnion. Prior to the separation of the two limbs of the amnion, the epiblast of the umbilical vesicle and the false amnion form a lining to the *zona radiata*. This membrane is the so-called *sub-zonal membrane* (*sz*), and it fuses with the *zona radiata* (*x*). The ovum is attached to the uterine wall by villi or processes which stick into folds of the epithelium of the uterus (fig. 236). So close is this connection that it is impossible to remove the embryo without tearing the uterine walls. The allantois a little later grows out of the hind-gut as a vesicle and forms a flat sac, which projects into the space between the amnion and the sub-zonal membrane. This allantois and the sub-zonal membrane fuse and form the *chorion* (fig. 236, *ch*), which more or less surrounds the ovum. Where the chorion does not surround the ovum, and where the yolk-sac

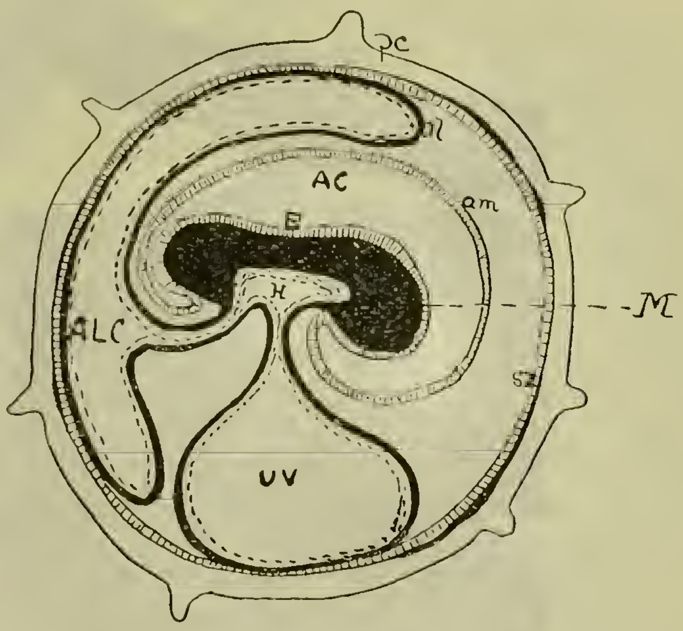


FIG. 235.—DIAGRAM OF FŒTAL MEMBRANES OF A MAMMAL. (After Turner.)

x, Zona with villi; *sz*, sub-zonal membrane; *E*, epiblast of embryo; *am*, amnion; *AC*, amniotic cavity; *M*, mesoblast of embryo; *H*, hypoblast of embryo; *UV*, umbilical vesicle; *al*, allantois; *ALC*, allantoic cavity. (From Foster and Balfour.)

and sub-zonal membrane unite, a false chorion is formed. Thus where the placenta is formed is the true chorion, the other part the false chorion.

From the outer surface of this chorion, which is highly vascular, villi grow out which fit into the crypts or pits in the uterus (*cr*). These villi may become much branched. Not only are the villi highly vascular, but the uterine pits are likewise. Here there takes place that interchange of blood by diffusion between the parent and fœtus.

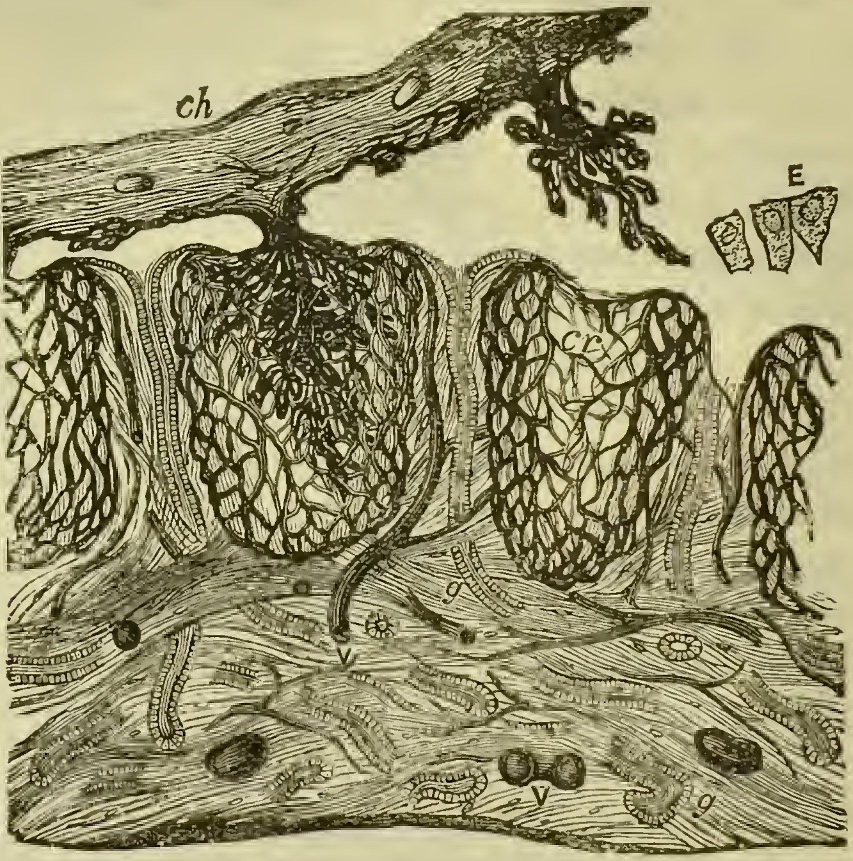


Fig. 236.—Vertical Section of injected Placenta of a Mare.

ch, Chorion; *cr*, uterine crypts; *g*, uterine glands; *V*, blood-vessels; *E*, epithelium. (Turner.)

The yolk or umbilical sac becomes smaller (fig. 237, *ur*), and may atrophy before the close of uterine existence. The allantoic stalk gives rise to two structures, the urinary bladder and a cord, the *urachus*, which connects the bladder with the umbilicus. These membranes are shed at birth, and sometimes with them the uterine mucous membrane comes away with the placenta. We thus get two forms of placenta, the *non-deciduate* and the *deciduate.* The non-deciduate placenta comes away from the uterine mucous membrane separately, whilst in the deciduate form both are so closely interlocked that they come away as the "afterbirth" together.

Varieties of Placentæ.

We can distinguish five kinds of placentæ—viz., the discoidal, the meta-discoidal, the zonary, the cotyledonary, and the diffuse placenta. The discoidal is found in the Rodents, Bats, and Insectivora; the meta-discoidal in Man and Apes; the zonary in Carnivora, Elephants, and the Hyrax; the cotyledonary in the Ruminants; the diffuse in the Horse, Pig, &c.

1. The *discoidal placenta.*—The amnion is small and surrounds the embryo. The yolk-sac is attached to the embryo by a very long stalk, and is closely applied to the greater part of the sub-zonal membrane, forming the *false chorion.* The allantois forms a moderate-sized sac, which below is applied to the sub-zonal membrane, and there forms the *true chorion* or *placenta.* From this placental area pass vascular villi into the uterine pits. This discoidal placenta is deciduate. A great space exists between the embryo and the false chorion, which is filled with fluid.

2. The *meta-discoidal placenta* (fig. 237).—Here a complete chorion is formed, the allantois entirely surrounding the inner wall of the sub-zonal membrane. The embryo is encircled by the amnion, which swells out almost to the placenta, only being separate from it by a gelatinous layer. The yolk-sac is very small. As the blastodermic vesicle grows it becomes related to three parts of the uterus. These three parts are thrown out at birth and are called *decidua.* One part of the uterus is reflected over the vesicle = the *decidua reflexa* (*f*); that part of the uterus around which the reflexa is attached is

known as the *decidua serotina* (*b*), and that part of the uterine wall not related directly to the vesicle, the *decidua vera* (*c*).

The chorion is directly attached to the *decidua reflexa* and *serotina*. The vascular connection between the reflexa and the chorion atrophies, whilst that between the serotina and the chorion increases, the villi becoming much branched and forming the *chorion frondosum*. This latter structure and the *decidua serotina* form the true placenta. This placenta is discoidal, but it is ventral, whereas the placenta of the rabbit is dorsal. At birth the placenta and the fused *decidua vera* and *reflexa* are all shed, and the ruptured blood-vessels of the uterine wall closed by its rapid contraction.

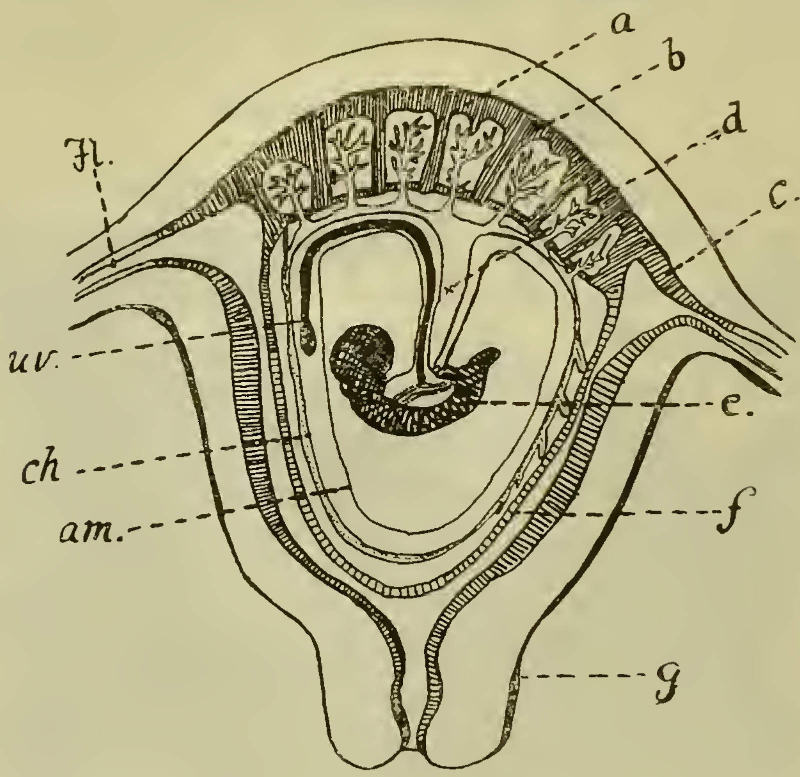


FIG. 237.—DIAGRAMMATIC SECTION OF PREGNANT HUMAN UTERUS WITH CONTAINED FŒTUS.

d, Allantoic stalk; *uv*, umbilical vesicle; *am*, amnion; *ch*, chorion; *b*, decidua serotina; *c*, decidua vera; *f*, decidua reflexa; *Fl*, Fallopian tube; *g*, cervix uteri; *a*, fœtal villi of placenta; *e*, embryo. (From Huxley, after Longet.)

3. The *zonary placenta*.—Here the placenta is in the form of a broad band. The yolk-sac never fuses with the chorion. At first the allantois fuses with the sub-zonal membrane, at one

part only forming a discoidal patch; but this grows out all round, and invades the whole of the sub-zonal membrane except at the poles. There is thus formed a broad placental band, where the villi closely unite with the uterine pits specially formed.

4. *Cotyledonary placenta* (fig. 238).—This is characterised by the villi of the placenta being found in round scattered areas, the *cotyledons*, which fit into corresponding thick areas studded with pits in the uterus.

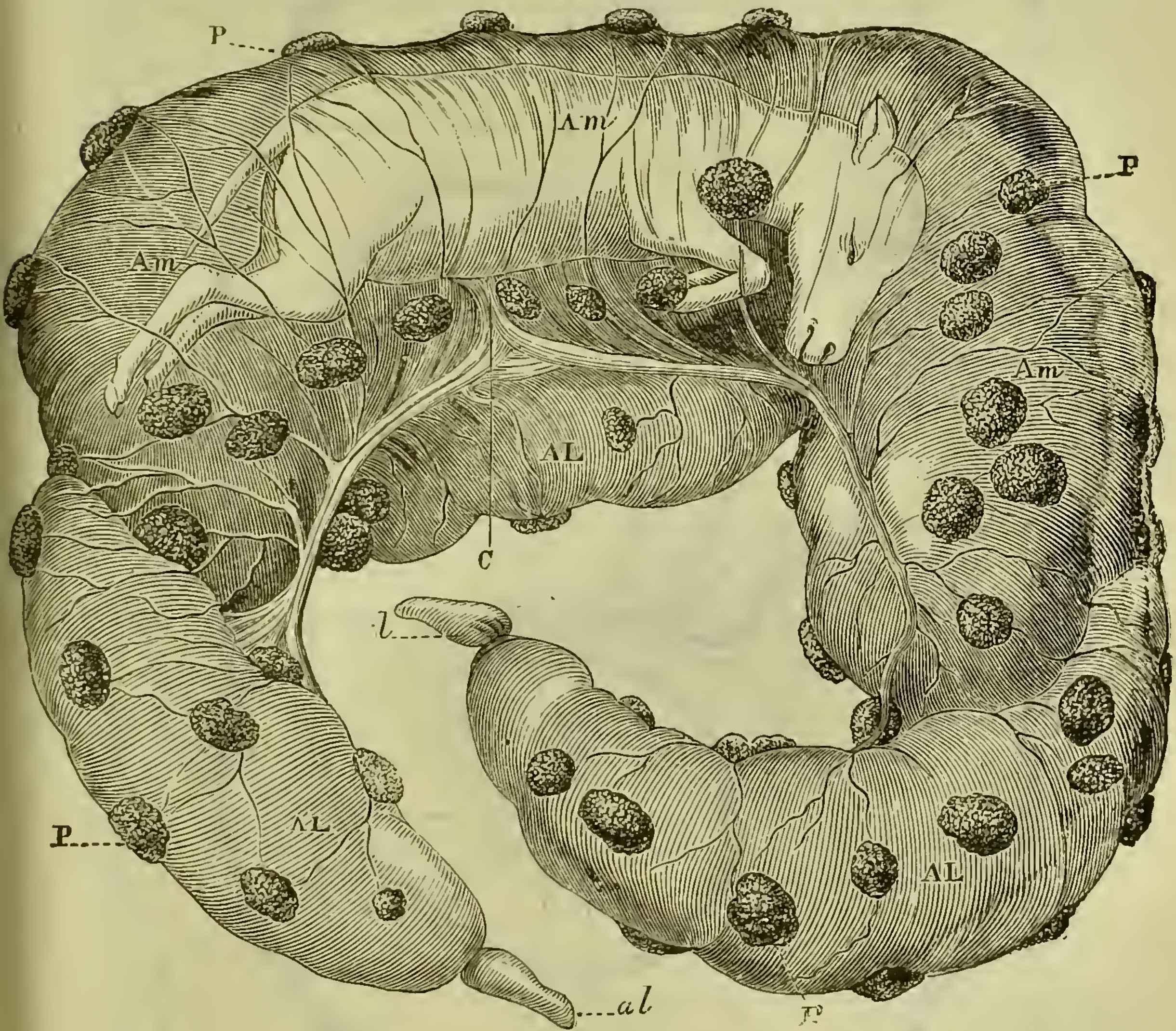


FIG. 238.—FŒTUS OF SHEEP.

AL, Allantois, seen beneath chorion; *Am*, amnion; *P*, *P*, placentæ on chorion; *C*, umbilical cord; *al*, *al*, extremities of allantoidean cornua. (Chauveau.)

5. In the *diffuse placenta* (fig. 239) the allantois (*al*) completely surrounds the embryo (*F*), and the whole chorion (*Ch*)

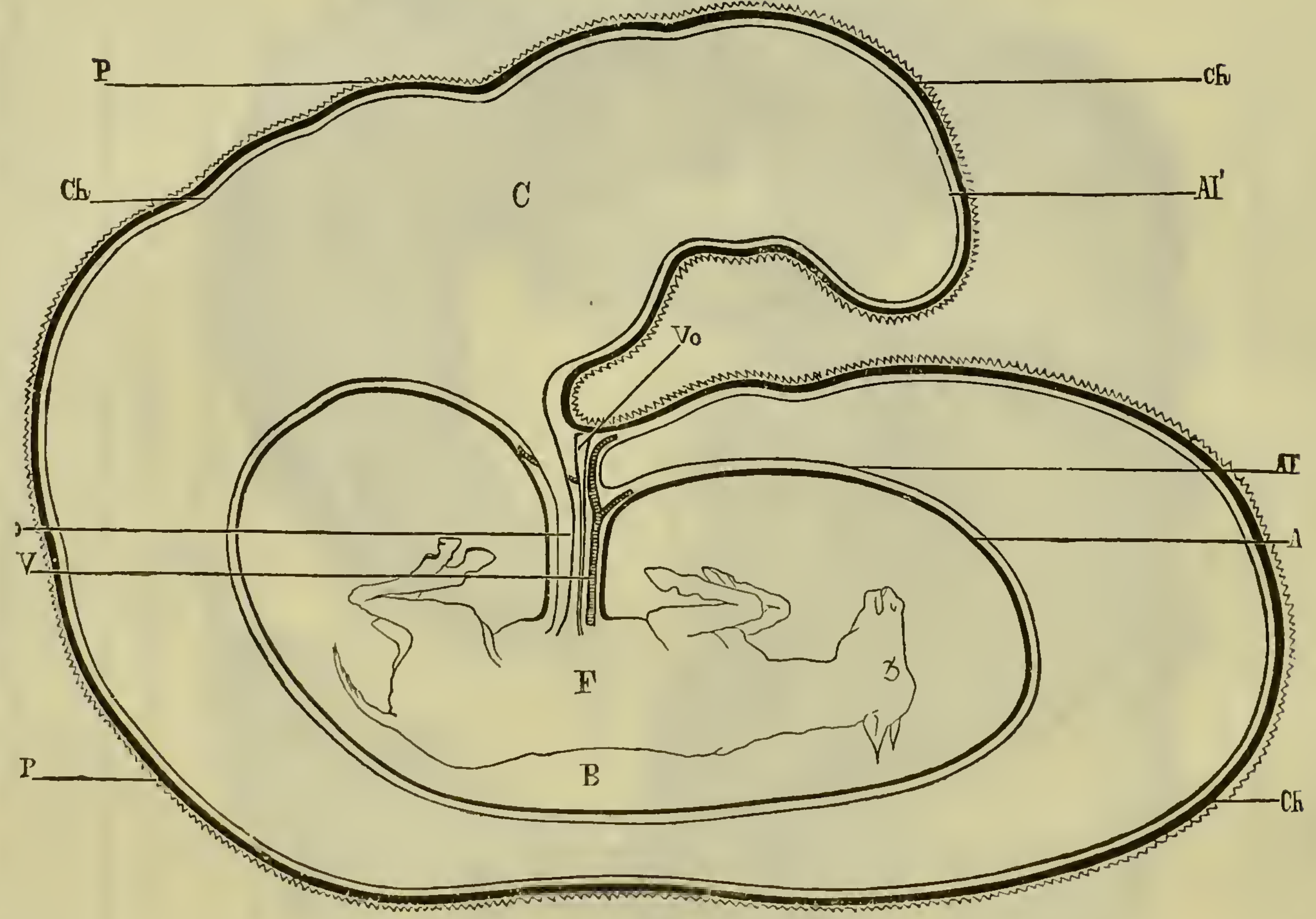


FIG. 239.—DIAGRAM OF PARTS OF FŒTAL HORSE, towards middle of gestation.

P, *P*, Placenta; *Ch*, *Ch*, chorion; *Al'*, external layer of allantois; *Al*, internal layer of allantois; *o*, urachus; *A*, amnion; *B*, cavity of amnion; *Vo*, remains of umbilical vesicle; *V*, vessels of umbilical cord; *F*, fœtus; *C*, cavity of allantoid. (Chauveau.)

has villi studded over it except at the poles, where small areas are devoid of them.

All mammals except the Monotremes and Marsupials have a placenta in one of these five forms.

The length of *gestation* in farm animals has been divided by Gurlt into seven periods. The last period and the dimensions of the embryo are given in the table below :—

SPECIES.	SEVENTH (LAST) PERIOD.	DIMENSIONS OF FŒTUS (at birth).
Mare	From 35th to 48th week	About 45½ inches.
Cow	" 33rd to 40th "	" 32½ "
Sheep	" 19th to 21st "	" 19⅗ "
Sow	" 15th to 17th "	From 9½ to 10⅘ inches.
Bitch	9th week . . .	" 6½ to 8¾ "

The weight of the fœtus of the mare at birth varies according to breed. The lowest, in the Corsican mare, is 35 lb. ; in a Suffolk-Boulonnaise mare, Chauveau mentions 135 lb. The weight of a calf at birth is about 2·31 parts of the cow, a lamb 10 to 11 lb., a pig 5 lb., and a chick 1½ ounce.

CHAPTER XIX.

MAMMALIA—*Continued.*

CLASSIFICATION OF MAMMALS.

BRITISH MAMMALS (DOMESTIC AND WILD).

MAMMALIA are divided into three sub-classes — namely, the *Ornithodelphia*, the *Didelphia*, and the *Monodelphia*[1]—which are characterised by the following features:—

A. The **Ornithodelphia** have the two uterine enlargements of the oviducts separate, forming two uteri, each of which opens direct into a cloacal chamber like a bird, and not into a single vagina. This cloaca also receives the rectum and ureters. Chorion absent. Here are placed the *Monotremata*, to which belong the *Echidna* and Duck-Bill (*Ornithorhynchus*).

B. The **Didelphia**, characterised by the uterine enlargements of the oviducts opening into two separate vaginæ, which have distinct apertures in the urogenital canal, the rectum being separated. Chorion absent. Coracoids reduced, not reaching the sternum. Males without cloaca. To this group belong the *Marsupialia* or Pouch-Bearers.

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[1] Huxley, in the 'Proceedings' of the Zool. Soc. for 1880, p. 649, proposed the following names for these three groups: (1) *Prototheria*, (2) *Metatheria*, (3) *Eutheria.* Dr Gadow, in his classification of the Vertebrata, follows Huxley's three divisions, and groups the Mammals in the following order:—

Sub-class 1. Prototheria (Monotremata, &c.)
Sub-class 2. Metatheria (Marsupials).
Sub-class 3. Eutheria.

Order 1, Edentata. Order 2, Trogontia (including the Rodentia). Order 3, Cetacea. Order 4, Sirenia. Order 5, Ungulata (including Hyracoidea and Proboscidea). Order 6, Carnivora. Order 7, Insectivora. Order 8, Chiroptera. Order 9, Primates.

C. The **Monodelphia**, which have the two uterine enlargements of the oviducts united to form one uterine cavity, with its two cornua, and by the single vagina, which is completely separate from the rectum. Chorion and placenta present. Coracoids reduced to a process only. This division contains all the remaining mammals, which include the following :—

(i) *Edentata* or Sloths.
(ii) *Sirenia* or Manatees.
(iii) *Cetacea* or Whales.
(iv) *Ungulata* or Hoofed Animals.
(v) *Hyracoidea* or Conies. }
(vi) *Proboscidea* or Elephants. } = Ungulata.
(vii) *Carnivora* or Beasts of Prey.
(viii) *Rodentia* or Rodents.
(ix) *Chiroptera* or Bats.
(x) *Insectivora* or Moles, Shrews, &c.
(xi) *Quadrumana* or Monkeys. }
(xii) *Bimana* or Man. } = Primates.

Seven of these orders only are met with in the British Isles. The other five need little consideration.

A. *ORNITHODELPHIA*

= PROTOTHERIA.

MONOTREMATA.

These are the lowest animals, and approach the Sauropsida nearer than other Mammalia. The two most noted forms are the Duck-Bill (*Ornithorhynchus paradoxus*) and the porcupine-like *Echidnas.* These animals all have a regular cloaca ; there are no teeth in Echidna, whilst the duck-bill has four horny pads in their place. The pectoral arch is like that of Sauropsids—namely, the coracoid bones reach the sternum, and an interclavicle is present. The pelvis is furnished with special tendinous ossifications, forming the peculiar "marsupial bones," although the female carries no pouch as in the marsupial animal. The Monotremes come from Australia, Tasmania, and New Guinea. The females have no nipples to the mammæ, and lay eggs covered by a flexible shell. These are the only oviparous mammals.

B. *DIDELPHIA*

= *METATHERIA*.

MARSUPIALIA or POUCH-BEARERS.

No marsupial animals exist in Europe. Their present geographical distribution is very limited: the majority are found in Australia and the adjacent islands, where the entire indigenous fauna is marsupial. A few species (Opossums) are found in America and others in the Indian Archipelago (*Macropus*, *Cuscus*, &c.) The "Pouch-Bearers" have distinct teeth placed in sockets, and the angle of the lower jaw is nearly always inflected. A "marsupial bone" is always present attached to the edge of the pelvis: its function in the female is to act as a support for the pouch and to aid the action of the mammæ. In the males, which have no pouch, it may be in some way connected with the testes. The "marsupium" or "pouch" is always present in the female, and has the nipples of the mammæ inside it: in this pouch the young, which are born in an immature state, are carried for some time by the mother. The long mammæ force their way into the young marsupial's mouth without its aid; as soon as they can suck naturally, they leave the pouch and return to it for nourishment whenever they require it. A peculiarity in the male is that the testes, which are in a scrotum, are situated in front of the penis and not behind as in most mammalia. In this group are the Kangaroos (*Macropodidæ*), Wombats (*Phascolomys*), Phalangers (*Phalangistidæ*), Opossums (*Didelphidæ*), and the carnivorous Tasmania Devil (*Dasyurus*), &c.

Fossil species are found in the Stonesfield slate of Oxfordshire, and previously in the Triassic rocks.

C. *MONODELPHIA*

= *EUTHERIA*.

UNGULATA or HOOFED ANIMALS.

The Ungulata or Hoofed Animals include several of our domestic animals, such as the horse, ass, mule, pig, goat, sheep, and oxen. It is one of the largest and most important orders of

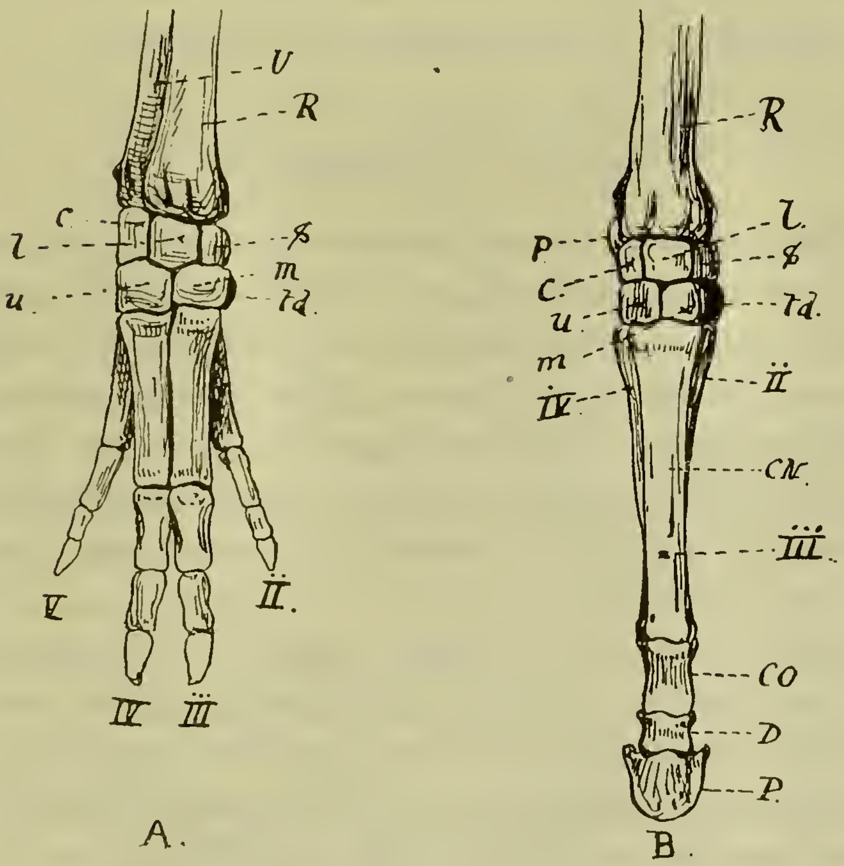

Fig. 240.—Feet of Ungulata.

A, Artiodactyle foot (Pig). B, Perissodactyle foot (Horse).

Mammalia. Ungulates have all four limbs touching the ground by the last toe-joint only, and that joint is enshrouded in a case or hoof of horn (except *Hyracoidea*). The hoof is an expanded nail. In no ungulate do we find more than four toes to each limb. Clavicles are absent. There are always two sets of teeth, milk-teeth and permanent teeth; the molars have always broad crowns (fig. 243), adapted for chewing and grinding vegetation, upon which all the Ungulata live. The Ungulata are divided into two sections:—

1. *Perissodactyla.*—Toes always odd in number on hind feet, either one or three (fig. 240, *B*). Stomach simple. Fibula articulates with astragalus.
2. *Artiodactyla.*—Toes always even in number, being two or four to each foot (*A*). Stomach complex. Fibula articulates with astragalus and calcaneum.

Section 1. **Perissodactyla.**

This section includes the horses, tapirs, and rhinoceros, in which the stomach is simple, and a large cæcum is present as seen in the horse. The hind-feet are odd-toed in all perissodactyla, and the fore-feet in many. The third toe always forms the functional axis. The dorso-lumbar vertebræ are never less than twenty-two in number, and the femur has always a third trochanter. If horns are present, they never have bony cores as in cattle.

We need refer to one family only, the EQUIDÆ, SOLIDUNGULA, or SOLIPEDS. The Equidæ are the horses, asses, and zebras. The features of these can be taken from the description of the horse already given. All our domestic varieties are considered one species, *Equus caballus.* At Solutré are immense bone-beds with horse remains: the descendants of these are probably the Ardennes horses, one of the long-headed races which seem very similar to the fossil ones of Solutré. From these also are descended the semi-wild horses in the delta of the Rhone and in Alsace. The two great races of horses are the Oriental and the Occidental. In the Oriental or Arabian we get the skull covering the brain strongly developed, and the facial part smaller; the enamel of the molars of the upper jaws have few folds, and the limbs are fine. The Occidental Horse has a much larger development of the facial part of the skull; the skull is long and narrow, the rims of the eye-cavities stand somewhat forward, and the enamel folds of the crescents of the upper molars are complicated. The bones are also thicker and more massive, but less hard, than the Oriental. These two main races of *Equus caballus,* the Arab and the cart-horse, have undoubtedly descended from a common stock, yet now represent two quite distinct races. Wild horses were once abundant in Europe and Asia, as their remains in the Diluvium testify, and from these our *Equus caballus* has descended. In America, although we have plenty of equine remains, the genus Equus never advanced in a wild state so near our present horse as did the diluvial horses of Europe and Asia.

The Ass (*E. asinus*) was domesticated before the horse. Unlike the horse, there are no warts or chestnuts on the hind-legs, and there is always a conspicuous line along the back, whilst the tail is long, with a tuft of long hair at the extremity. The ass is a native of North Africa, and probably descended from either the Onager (*E. onager*) or Kiang (*E. hemionus*). It is also said by some to be descended from *E. tæniopus* of S.-E. Asia.

Fossil horses exist in the Eocene rocks of America, known as *Eohippos*, in which the fore-feet have four toes and the remnant of a fifth, and the hind-feet three. The Eohippos was about the size of a dog. A division higher in the Eocene, another genus, *Orohippos*, makes its appearance. In the Miocene rocks we get another form, the *Miohippos*, which has three toes on each foot, all touching the ground. In the Pliocene of Europe we find a fossil horse called *Hipparion* in which three toes exist on each foot, but the middle one alone touches the ground. Towards the end of the Pliocene period we get the

Protohippos in America, whose foot resembles that of Hipparion —the existing genus *Equus* not appearing until Post-Pliocene times.

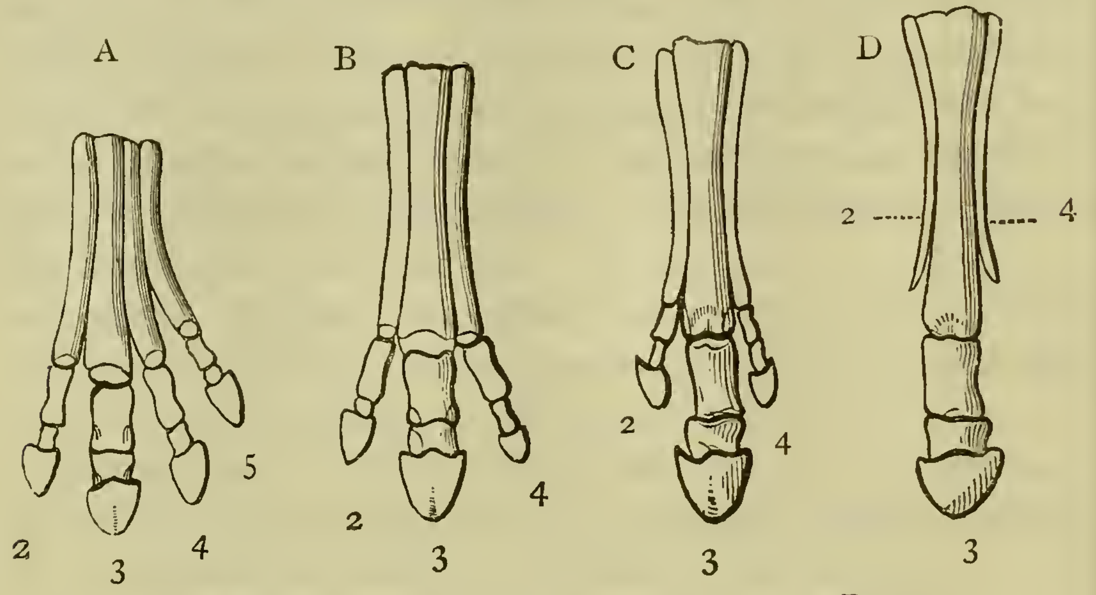

FIG. 241.—SKELETON OF FOOT IN VARIOUS FORMS OF EQUIDÆ.

A, *Orohippos* (Eocene); B, *Anchitherium* (Upper Eocene and Lower and Upper Miocene); C, *Hipparion* (Upper Miocene and Pliocene); D, *Equus* (Pliocene and Recent). (Nicholson, after Marsh.)

There seem to be two distinct lines of descent, one in America and one in Europe. In America the stages are Eohippos, Orohippos, Mesohippos, Miohippos, Protohippos, Pliohippos, and Equus. In Europe, Hyracotherium, Palæotherium, Anchitherium, Hipparion, and Equus.[1]

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[1] The living and extinct horses are tabulated as follows by Dr Gadow:—

Equidæ. Lower molars quadrituberculate, or with two transverse ridges curved into two half-moons. Toes, $\frac{4}{3}$, $\frac{3}{3}$, or $\frac{1}{1}$. Since Eocene.

Hyracotherium	Toes, $\frac{4}{3}$.	Lower Eocene, England.
Eohippos		Lower Eocene, Wyoming.
Palæotherium	Toes, $\frac{3}{3}$.	Eocene to Miocene, Europe and U.S.A.
Mesohippos		Lower Miocene, Dakota.
Anchitherium		Upper Miocene of Europe = Miohippos, U.S.A.
Hipparion .	Toes, $\frac{3}{3}$.	Upper Miocene of Europe, Asia, and U.S.A.
Protohippos .	Toes, $\frac{3}{3}$.	Pliocene, U.S.A.
Pliohippos .	Toes, $\frac{1}{1}$.	Pliocene, U.S.A.
Hippidion .	Toes, $\frac{1}{1}$.	Pleistocene, S. America.
Equus . .	Toes, $\frac{1}{1}$.	Since Miocene in India; since Pliocene in Europe. During Pleistocene cosmopolitan, excluding Australian region.

('Classification of Vertebrata,' p. 47.)

In America the horse died out, but the line continued in Europe and Asia to the present day.

Thus we have every gradation from a four-toed horse to the existing one-toed animal.

The Age of the Horse told by its Teeth.—The teeth of the horse vary with age, so that we can tell approximately their age by an examination of the mouth. The incisors of the upper jaw appear sooner than those of the lower jaw. The front milk-incisors come through the gum about a week after birth, the middle milk-incisors at the age of five weeks. At nine months the corner milk-incisors are apparent. The permanent incisors appear as follows: the front when the horse is two and a half, the middle when three and a half, the corner ones when four and a half years old. The milk-incisors are distinguished by being shorter and whiter and with a narrower neck than the permanent ones; they also become gradually shorter, which is not the case with the permanent incisors.

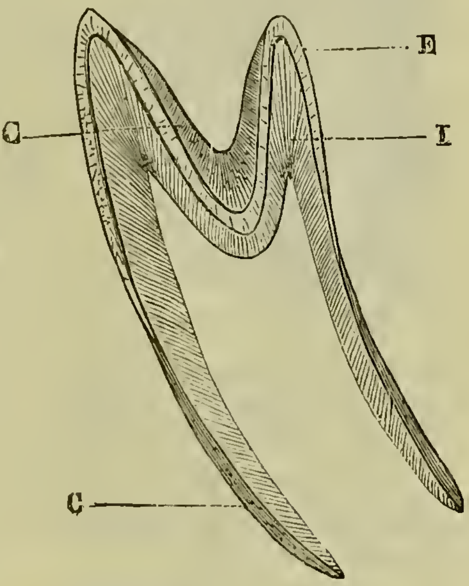

Fig. 242.—Section of Horse's Incisor Tooth. (Chauveau.)

I, Dentine; E, enamel; C, cement. The dentine envelopes the pulp-cavity; in the complete tooth it is yellowish; it forms on the table the dental star. The enamel covers the dentine; when worn down it presents two rings, an outer and an inner. The cement lies over the enamel, and is thickest in the hollows and at the bottom of the fangs.

The number of back teeth at birth, or soon after, is twelve, three on each side of each jaw; these are in the position of the three first molars. The permanent molars appear as follows: the 1st and 2nd at about two and a half years; the 3rd at three and a half years; the 4th at from ten to twelve months; the 5th at two years, and the 6th at four years. The true molars—that is, the fourth, fifth, and sixth double teeth—have no milk-teeth in their place.

The date of appearance of the canines—the *tushes*—in the male is variable.

The normal number of teeth in a horse with a so-called "full mouth" is forty — namely, $i\frac{3-3}{3-3}$; $c\frac{1-1}{1-1}$; $pm\frac{3-3}{3-3}$; $m\frac{3-3}{3--3}$ —the canines being absent in the mare.

Wolf-teeth are single-fanged teeth, sometimes present in front of the back teeth, in the upper jaw generally. Both "tushes" and wolf-teeth are permanent, but the latter are often soon shed.

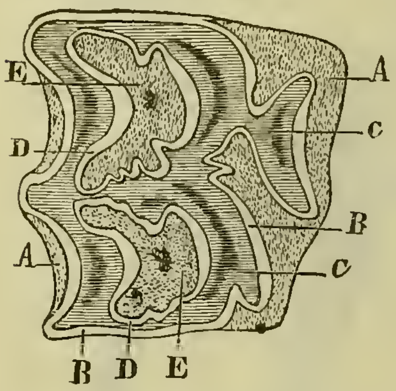

FIG. 243.—TRANSVERSE SECTION OF HORSE'S UPPER MOLAR. (Chauveau.)

A, External cement; B, external enamel; C, dentine; D, internal enamel; E, internal crusta petrosa.

The structure of the molars resembles that of incisors, but is more complicated. The internal cavity is much diverticulated and enveloped by dentine. The enamel is placed over it, and doubled in as in the incisor. There is seen on the worn table an external covering of enamel and two circles of central enamel surrounding the two areas of internal cement. The cement fills in the depressions on the face of the crown, &c., and is very abundant.

The following may be taken as indications of the age from birth to thirty years old:—

1. *At birth.*—The front milk-incisors can be plainly seen under the gums.
2. *At one month.*—The front milk-incisors are through the gums, the upper and lower ones meeting, the middle ones just show.
3. *At five months.*—The middle and lower incisors meet and the corner ones just show.
4. *A yearling.*—The corner incisors are through but do not yet meet.
5. *A two-year-old.*—Central enamel of middle incisors of both jaws now forms a complete ring.
6. *At two and a half years.*—Front milk-teeth fall out in upper jaw and become replaced by permanent ones.
7. *A three-year-old.*—The four permanent incisors are nearly level (front incisors).
8. *At four years.*—Middle milk-incisors are out and permanent ones come. Tushes begin to show.
9. *At five years.*—Permanent incisors all level. The central

enamel of the front and middle incisors show complete rings. Tushes quite out of gum.

10. *At six years.*—Inner edge of corner incisors worn flat, central enamel in complete ring. Tables of front incisors oval. The cement of the front incisors has nearly gone.
11. *At seven years.*—The posterior edge of the lower corner incisor is well in advance of that of upper jaw, giving the upper incisor a hook-like projection.
12. *At eight years.*—Lower incisors with oblique direction. A yellow transverse line—the dental star—is well marked in the front incisors.
13. *At ten years.*—Tables of front and middle lower incisors become rounded and the central enamel triangular. The front incisors also have become longer and narrower, and more or less triangular in shape. This becomes more and more advanced with age.
14. *At thirteen years.*—Central enamel has nearly gone from lower incisors.
15. *At twenty-one years.*—The middle and corner incisors converge inwards.
16. *At thirty years.*—The incisors are in nearly a straight line, and the tables are broadest from the front to the back.

Section 2. **Artiodactyla.**

Toes even in number, either two or four. The functional axis passes between the third and fourth toes. Dorso-lumbar vertebræ nineteen, and there is no third trochanter to the femur. The horns when present are always supported on bony cores or projections from the frontal bones of the skull (fig. 247, 3). The stomach is (with the exception of one group) more or less complex, there being several divisions, some of which are probably dilatations of the œsophagus; the cæcum is very small and simple in form. The families for our consideration are the *Suidæ* or Pigs, and the Ruminant families *Cavicornia* or *Bovidæ* (Oxen), *Ovidæ* (Sheep and Goats), and the *Cervidæ* (Deer).

NON-RUMINANTS (*=BUNODONTA*).

The non-ruminating Artiodactyla are often called Pachydermata on account of the thick bristly skin, and have four toes in the Hippopotamus touching the ground; in the Pigs two are rudimentary. The molars are tuberculate.

The Suidæ or Pigs have two functional toes, the other two not touching the ground—the so-called "dew-claws" of the pig. Now and then the first digit is present, arising from the trapezium, but such cases are very rare. Canine teeth are large in the males, forming the "tusks" of the boars. The teeth (fig. 244) vary in number in each species of pig. In the domestic pig the dental formula is—

$$i\,\frac{3—3}{3—3};\ c\,\frac{1—1}{1—1};\ pm\,\frac{3—3}{3—3};\ m\,\frac{4—4}{4—4} = 44.$$

The stomach of the pig is simple like that of the horse, but less curved on itself; the cardia has a small conical dilatation, like a cowl turned backwards. The capacity is from $1\frac{1}{2}$ to 2 gallons. The blunt snout is provided with a peculiar bone called the "scooping-bone." The pig's intestine resembles that of the ox; it is 72 feet long. The mesentery that suspends the small intestine contains an elongated mass of lymphatic glands, the so-called *mesenteric gland*. The cæcum is sacculated as in the horse, with three longitudinal muscle bands. The penis is twisted spirally when flaccid. The testicles are round, and the scrotum narrow and but little detached. At the prepuce is a special pouch which secretes an unctuous fluid, which even taints the flesh. The mammæ are usually ten in number. In the brain there are few cerebral convolutions. There are four teen pairs of ribs in the pig ; the carpus consists of eight bones, the trapezium being fully developed ; there are also seven bones in the tarsus.

Most of our domestic swine have probably descended from the Wild Boar (*Sus scrofa*). The wild boar at one time inhabited this country, but has long since been extinct. It is

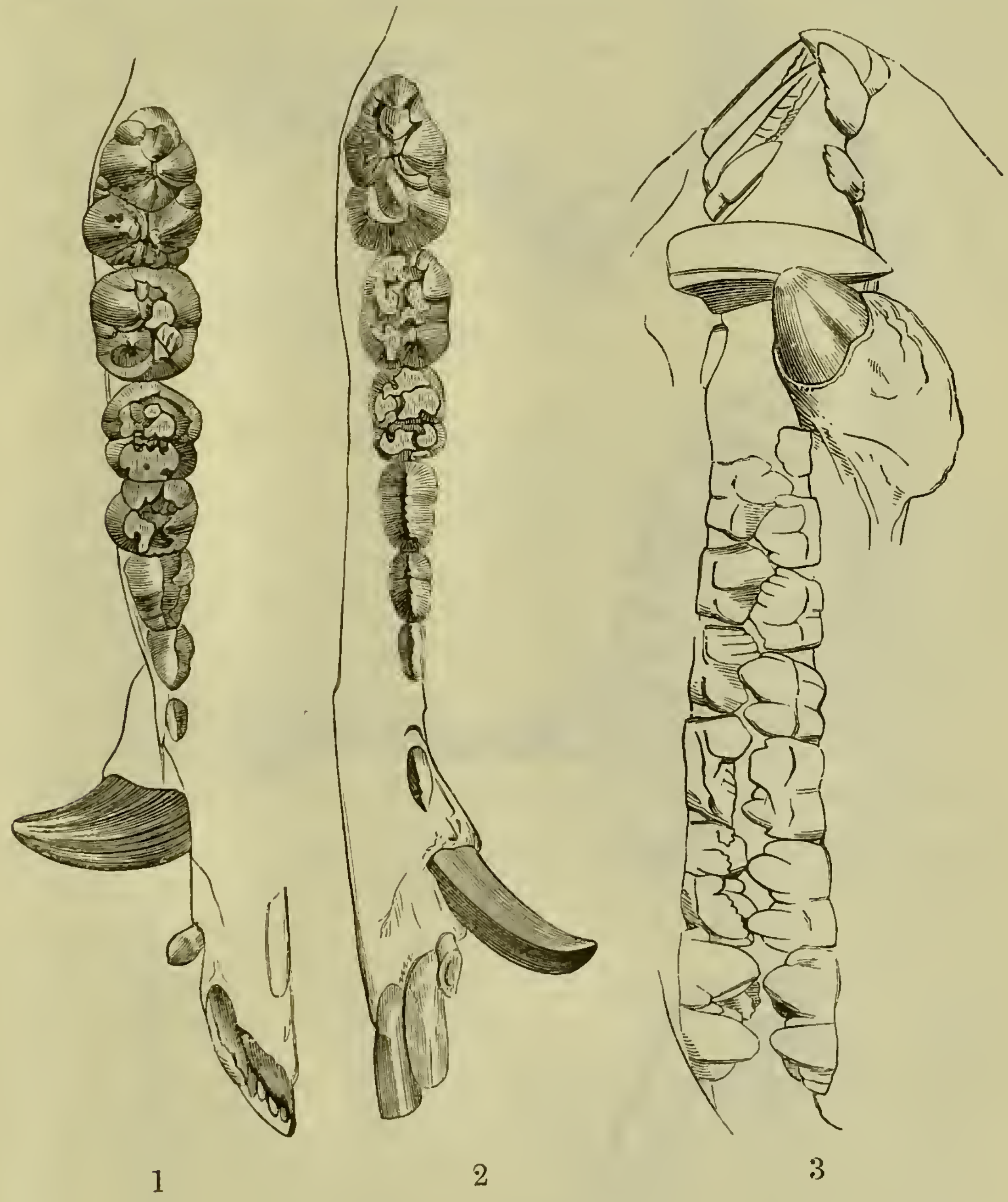

Fig. 244.—Teeth of Pig.

1. Upper teeth, table surface ; 2, lower teeth ; 3, lateral view of jaws. (Chauveau.)

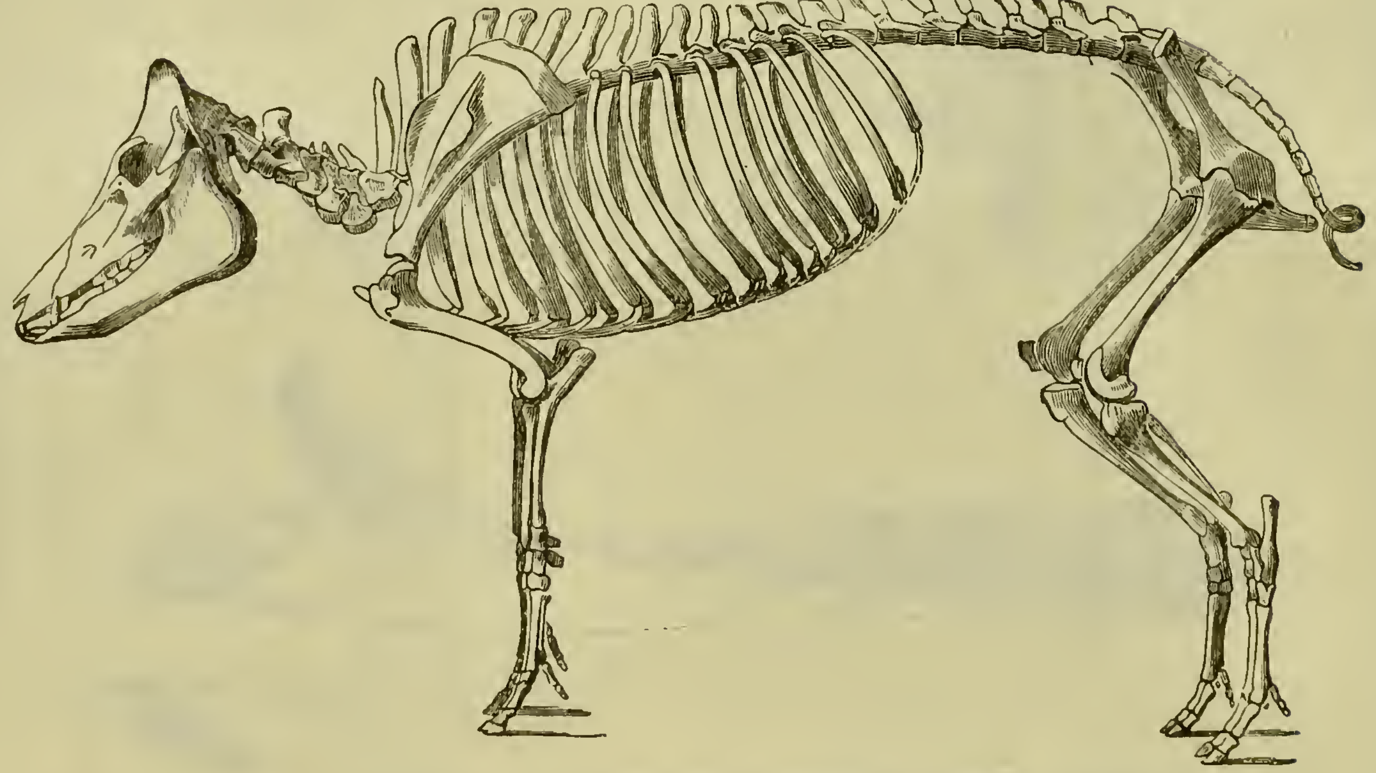

Fig. 245.—Skeleton of Pig.

Note prominent occipital ridge; distinct metacarpals and metatarsals (2-5), 2 and 5 forming the dew-claws, and 14 pairs of ribs. (Chauveau.)

black to rusty-brown in colour when adult, and where it appears on the Continent seems to revel in damp thickly vegetated areas, hiding during the day and coming out at night to feed. The food consists of roots of various kinds, corn, potatoes, acorns and other nuts, and insects, worms, &c., in the soil, and even voles. The wild boar when fully mature often attains the length of seven feet from the snout to the tip of the tail. The young are white marked with dark-brown.

The habits of the domestic pigs are much the same as *S. scrofa*: especially to be pointed out is the great benefit to be derived from keeping them in orchards, where they do inestimable good in devouring noxious insects.

RUMINANTS (=*SELENODONTA*).

The Ruminants have two toes on each foot, each toe having a separate hoof: there may also be two supplementary hoofs at the back of the foot. If one examines the skeleton of the ox, it will be observed that the two metacarpal and metatarsal bones have joined to form the "cannon-bone." The tubercles of the molars are transformed into longitudinally placed half-moons.

The Ruminant Stomach.—The stomach (fig. 246) is peculiarly constituted, consisting of four divisions—namely, (1) the *rumen* or paunch; (2) the *reticulum* or honeycomb stomach; (3) the *manyplies*, psalterium, or omasum; and (4) the *abomasum* or rennet stomach. The paunch is where large quantities of partly masticated vegetable food is stored. This is brought back to the mouth, where it is mixed with saliva, chewed up by the grinding teeth, and reduced to a fine pulp, the so-called "chewing of the cud." This food then passes down the gullet, and moves along a "gutter" called the "œsophageal groove" into the omasum. The paunch equals nine-tenths of the entire abdomen and lies in the left flank, the other three divisions forming a chain along the front of its left side. In the rumen the food is moistened. The *reticulum* is internally divided into a number of polygonal spaces on its walls; it is small in capacity, and acts especially as a reservoir for liquids. The omasum receives the "cud." This division has its walls thrown up into a number of deep folds longitudinally disposed, and placed so close together that they resemble the leaves of a book: we can recognise three series of them of different sizes. The food, after being crushed between the leaves, is passed through this into the fourth division, the abomasum or true digestive stomach. Here the food is subjected to the action of the gastric juice, and undergoes the chief digestion. It is called the rennet stomach because of a substance formed by the secretion of the peptic cells going by that name, the rennet used in cheesemaking and in "junkets" being obtained from the salted stomachs of calves. One must look upon the first three chambers of the ruminant stomach as being dilatations of the œsophagus only. As much as sixty gallons of liquid can be stored in the stomach of an ox! The intestinal canal is very long. The small intestine in the ox is twice the length of that of the horse, but is smaller in diameter (= 49 yards). The

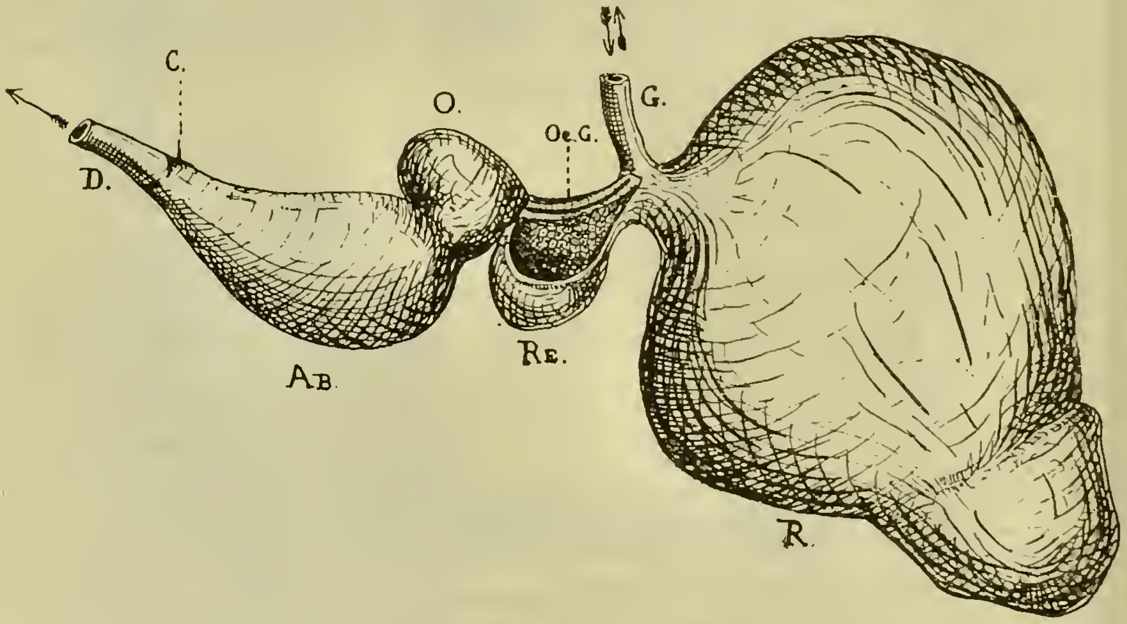

Fig. 246.—Stomach of Ruminant.

R, Rumen; *G*, œsophagus; *Oe.G*, œsophageal groove; *Re*, reticulum; *O*, omasum; *Ab*, abomasum; *D*, duodenum; *C*, constriction.

cæcum has no bulges or longitudinal bands. The large intestine is longer than in the horse (33 to 39 feet), and holds from six to seven gallons.

Ruminant Dentition.—Another character of Ruminants is the dentition. There are no incisor teeth in the upper jaw, their place being taken by a horny pad on the gums of that jaw against which the lower incisors cut; neither are there any upper canines. Behind, there are six teeth, three premolars and three molars. The lower jaw has six incisors and two canines, which are small; next follows a long edentulous space, and then three premolars and three molars on each side. The typical Ruminant dental formula is as follows:—

$$i\,\frac{0—0}{3—3};\ c\,\frac{0—0}{1—1};\ pm\,\frac{3—3}{3—3};\ m\,\frac{3—3}{3—3}=32.$$

Some deer (*Cervidæ*) and camels have canines above, and other slight differences.

The ruminant's lungs differ from the horse's in that the left lobe is divided into two and the right into four. Ox, sheep, and goat are characterised by the distinctness of the lobules.

FAMILY CERVIDÆ (DEER).

The *Cervidæ* or deer are noted for their "antlers," which, except in the reindeer, are present in the males only. The antlers are branched horns, and are solid structures, not hollow as the horns of cattle. They are carried on bony cores on the frontal line. The antlers are cast annually, and reproduced every year at or after the breeding or "rutting" season. At first the antlers are simple, cylindrical, unbranched structures covered with a hairy sensitive skin, the "velvet"; but later the vessels to this skin dry up, and the skin splits, peels off, and is rubbed off by the deer against the trees and fences. The horns in the second year have a side branch (tyne); in the third year there are three points, then known as the "sorel"; the four-year-old, in some deer, has four points, the so-called "staggard"; whilst a five-year-old or "stag" has five or more tynes. A strong-smelling waxy secretion is formed beneath each eye from a sebaceous gland.

Three species of Deer are found in Britain — namely, the Red-Deer (*Cervus elaphus*), the Roebuck (*C. capreolus*), and the Fallow-Deer (*C. dama*).

The *Red-Deer* (*C. elaphus*) is undoubtedly a native of Britain, and is still found wild on Exmoor and the Quantocks in the south, and in Scotland. The antlers are rough, and normally consist of two front branches, the "brow-" and the "bez-tyne," a middle branch called the "tres," and a "crown." In colour the red-deer varies from brown to reddish-brown, becoming brighter in summer, with a creamy patch on the tail. A stag weighs from 180 to 280 lb. The calves are spotted with white in their first coat, which is cast in October and November. They breed in autumn, and parturition takes place in May and June. Two calves may be produced. The horns, which often reach a great size in the "stag," are shed in February or March. It is strange how few of these cast horns are found: those that one does come across are usually single antlers. Stags no doubt eat the antlers after being shed; and others may, as Mr Jeffreys thinks, be covered up by the stag with leaves and brambles. Red-deer are often very destructive, destroying agricultural produce, not only by eating it, but far more by trampling it down. Farmers round Exmoor would sooner suffer this loss than destroy such sporting animals. They also bark young trees and eat the tender shoots in forests to an injurious extent. Around Exmoor one often sees fields of wheat spoilt by them, potatoes taken from the ground, and cabbages quite stripped. The stag only eats the top of the turnips and throws the root over his shoulder, whilst the hinds eat the turnips down to the ground. The excellent sport they afford quite makes up for the local harm they may do.

The *Roebuck* (*C. capreolus*), once very abundant in England, is now chiefly confined to the wilder regions of Scotland. It is found in Cumberland, Dorsetshire, and Essex, and may be seen in a few parks. It has a long winter coat of a dull brown colour: in summer the coat is reddish-brown, with a white patch on the rump. The legs are long and slender and the antlers small,—never any "brow-tynes," and as a rule only three terminal branches present. They are shed in December and January. An adult roe weighs about 45 lb. The fawns are spotted with white, and are born in April and May. As a rule, each roe gives birth to twins. The roebuck breed about August.[1] They pass the day in open spaces in the woods, coming into the fields to feed, especially upon standing corn and clover. Much damage may be done, where they are abundant, if they get into cornfields. Grass and shoots of oak and spruce form the chief food.

The *Fallow-Deer* (*Cervus dama*) is not a native of England. It stands about three feet high. The antlers are dilated towards their extremities. They live in herds.

CAVICORNIA (OVIDÆ AND BOVIDÆ).

The other Ruminants interesting to us are the *Cavicornia*, which include the Sheep, Oxen, and Goats. In the Cavicornia there are never any incisors or canines on the upper jaw, the hardened gum taking their place. The dental formula is as follows:—

$$i\,\frac{0-0}{3-3};\ c\,\frac{0-0}{1-1};\ pm\,\frac{3-3}{3-3};\ m\,\frac{3-3}{3-3}=32.$$

Both male and female may have horns, or the male alone may be horned. The Cavicornia have these structures very differently formed to the antlers of the Cervidæ. They are persistent, and not shed as in deer; moreover, they consist of a bony core at the base, which is covered by a hollow case of *horn*. The feet of the Cavicornia are always cloven. Here belong the

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[1] Dr Bischoff has shown that the fertilised ovum remains dormant for four and a half months before development proceeds.

Antelopes as well as Oxen and Sheep. The former have annulated or twisted horns.

Ovidæ (*Sheep and Goats*),—These animals have short legs and heavy bodies. The Goats (*Capra*) have horns in both sexes, and a tuft or beard of long hair on the throat. The domestic Goat (*Cavra hircus*) is descended from the wild goat of Persia and the Caucasus, the *Capra ægagrus*, which lives in herds in mountainous districts.

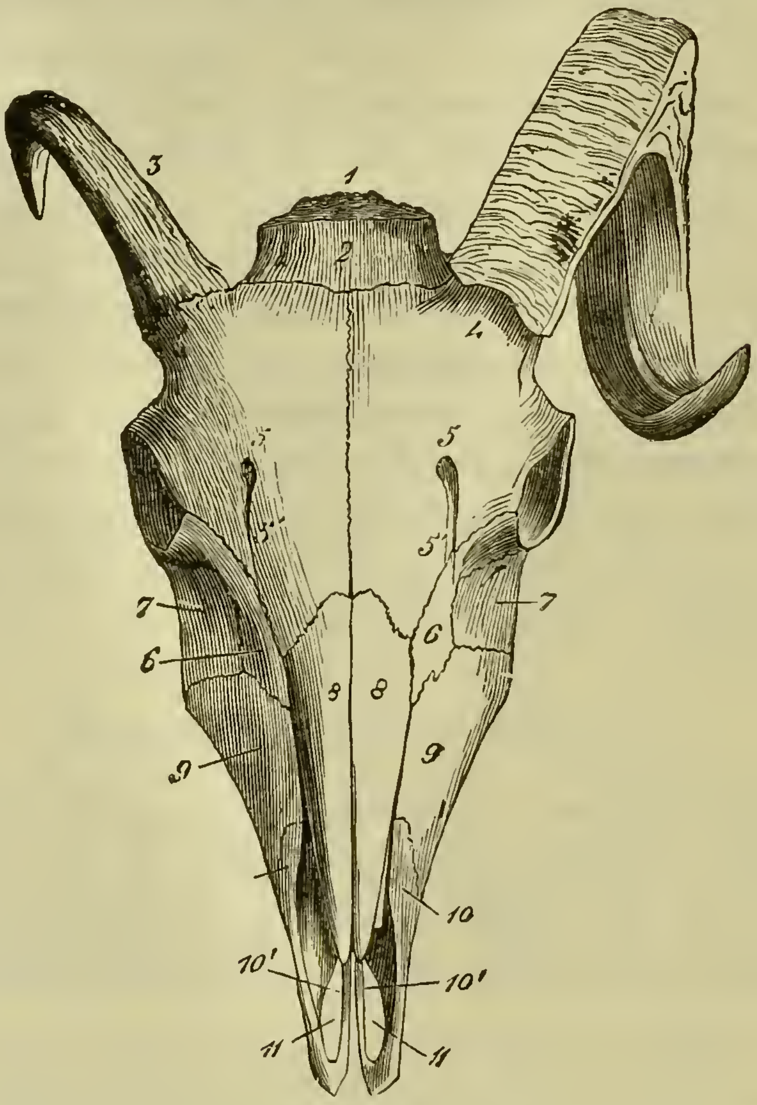

Fig. 247.—Skull of Ram.

1, Occipital bone; 2, parietal; 3, core of right frontal bone; 4, left covered by its horn; 5, supra-orbital foramen; 5′, channel descending from it; 6, lachrymal bone; 7, malar bone; 8, nasal bone; 9, supermaxillary; 10, premaxillary; 10′, its internal process; 11, incisive opening. (Chauveau.)

Sheep (*Ovis*) never have a beard, and the horns are spirally

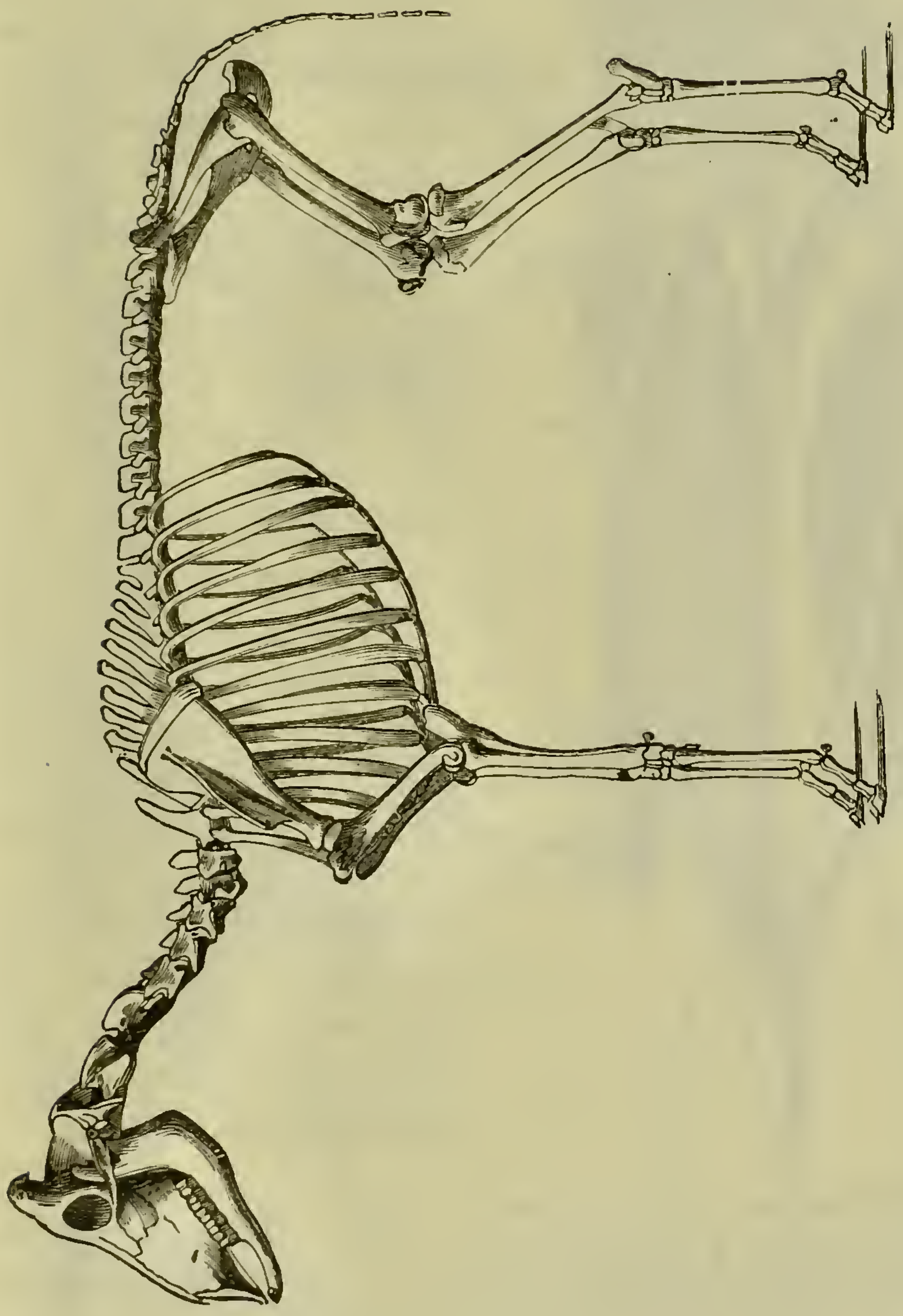

Fig. 248.—Skeleton of Sheep. (Chauveau.)

Note cervicals longer than in ox, and longer forearm. Thirteen pairs of ribs as in oxen.

twisted. The carpus consists of six bones in the sheep and ox, — four in the first row, two in the second, the magnum and trapezoid being fused together. Internally the sheep is much like the ox, but in the ram there is no prostate gland, and the penis is remarkable for the two lateral folds disposed like wings at the base of the glans. Horned varieties of sheep may have the horns in both sexes (blackfaced sheep) or only in the male (merino sheep). All sheep are natives of the Old World, but from what species our various domestic breeds have originated we do not know. Probably some of the horned varieties with short tails have sprung from the "moufflon" of Sardinia and Corsica.

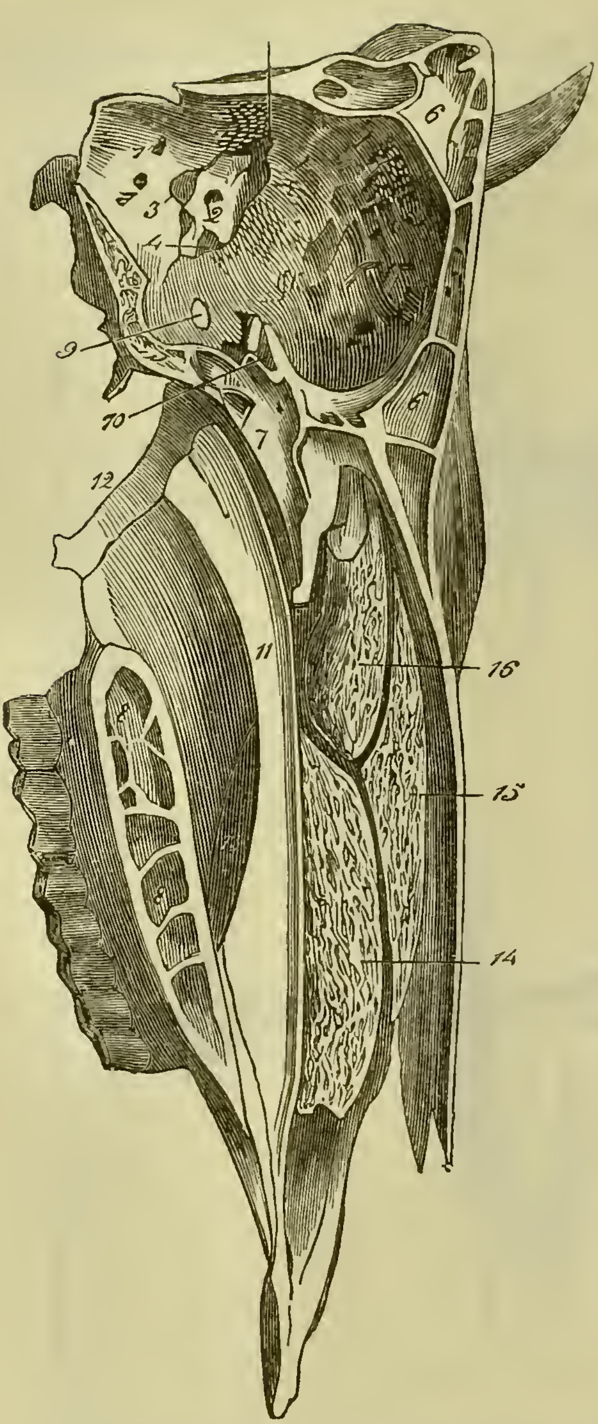

Fig. 249.—Median Section of Ox's Head.

1, Condyloid foramen; 2, internal auditory hiatus; 3, anterior foramen lacerum; 4, posterior ditto; 5, intra-cranial orifice of parieto-temporal bone; 6, bony plate separating frontal sinus; 7, lamina isolating sphenoidal sinus; 8, lamina isolating the palatine part of the maxillary sinus; 9, oval foramen; 10, optic fossa; 11, vomer; 12, pterygoid; 13, large opening leading into maxillary sinus, closed by pituitary membrane when fresh; 14, maxillary turbinated bone; 15, ethmoidal turbinated bone; 16 great ethmoid cell. (Chauveau.)

Oxen (*Bovidæ*). — The oxen never have spirally twisted horns. They are provided with an immense rumen, and all chew the cud. The skeleton of the ox (fig. 250) differs from that of

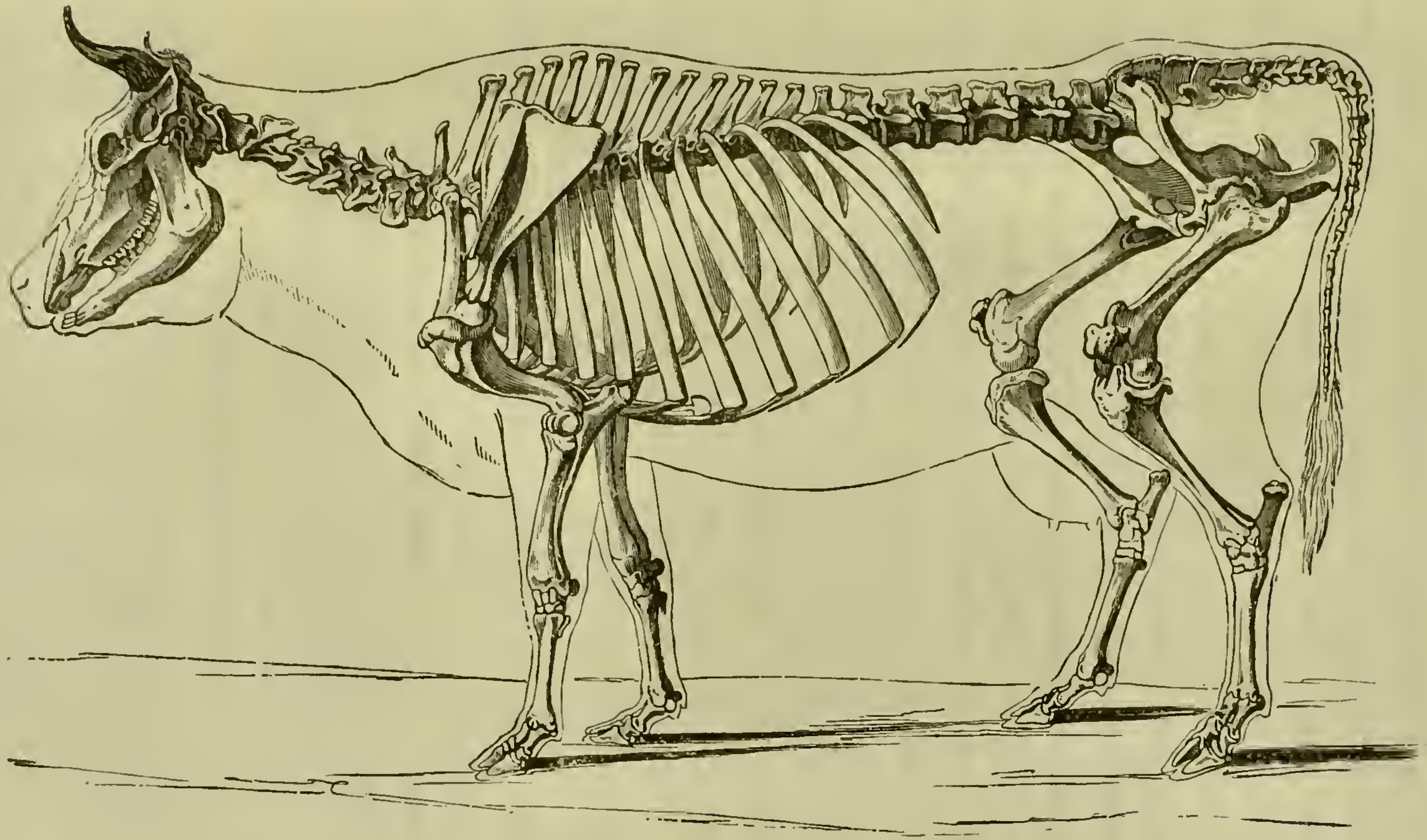

Fig. 250.—Skeleton of Cow. (Chauveau.)

Note the broad ribs (13 pairs), two toes, broad scapula, absence of teeth on premaxillary bones, great development of frontal bones, and rudimentary third metacarpal.

the horse in that the ribs are broader, longer, and flatter, and there are thirteen on each side; the sternum is flat and not keel-shaped; the scapula is broader at the top, and the premaxillary bones do not carry teeth. The frontal bones of the skull are enormously developed (fig. 249). The upper part of the frontal bone forms the pole. The pole is thick, owing to the sinus in the frontal bones, and bears laterally the conical bony cores that support the horns. The ox, sheep, and goat have a third turbinated bone in the nasal cavities. In the foot of the ox and sheep the cannon-bone is composed of the fused third and fourth metacarpals and metatarsals; each digit is free, and carries a hoof. A rudimentary third metacarpal is seen in the ox. The ulna, as in the sheep, extends the whole length of the radius. The kidney of the ox is lobulated. The sexual organs of the Bull have certain peculiarities: there are no Cowper's glands, the penis is long and thin, and lies in an S-shaped curve when retracted. Most of the wild species are capable of domestication. The parent stock of our various breeds of cattle is not known for certain. Some suppose that the beautiful white Chillingham cattle, once wild over England, and now only preserved in one or two places, are descendants of the wild cattle of Europe, the Urus or mountain bull (*Bos primigenius*), which existed in numbers in a wild state in Gaul at the time of Cæsar's invasion. The three most important races of oxen which have been traced back to *B. primigenius* are—

(i) The Brachyceros race (Appenzell cattle).
(ii) Primigenius race (Holland cattle).
(iii) Frontosus race (Bern cattle).

Another wild Bovis in Europe was the so-called British Shorthorn (*Bos longifrons*), now extinct. Very probably most of our smaller short-horned varieties are descended from this wild species. Another wild species in Britain was the Auroch (*Bos bison*), a large species, which still exists in a wild state in the Caucasian forests.

CARNIVORA or BEASTS OF PREY.

Carnivora, which include all the Beasts of Prey and the Seals and Walruses (*Pinnipedia*), have always two sets of teeth, covered by enamel. Teeth are of four kinds—incisors, canines, premolars, and molars. The incisors are generally $\frac{3-3}{3-3}$, the canines $\frac{1-1}{1-1}$, and are always large and well developed, pointed and sharp; the premolars and molars have sharp cutting edges. Some molars and premolars, however, have crowns adapted for bruising. As a general rule, the shorter the jaw the fewer the molar and premolar teeth, and the more carnivorous the habits of the animal. The jaws can only move in a vertical direction. The temporal muscles are strongly developed, so that the head is rather broad. All carnivora have sharp claws, more or less curved, generally five, rarely four toes, a short intestine, and abdominal teats. The fœtus is enclosed in a deciduate and zonary placental membrane. The two sections of Carnivora are as follows:—

1. *Pinnipedia* = Seals. Fore and hind limbs short, and in the form of swimming-paddles.
2. *Fissipedia* = Dogs, Cats, Tigers, &c.[1]

Fissipedia.

In this section we find the Weasels (*Mustelidæ*), the Dogs and Foxes (*Canidæ*), and the *Felidæ* or Cats.

Mustelidæ or Weasels.

The body elongated and slender; legs short; toes five, armed with sharp curved claws. The skull is long and flat, with a tuberculate molar on each side of the upper and lower jaws. All the *Mustelidæ* have curious anal glands which emit a strong-smelling odour; these are greatly developed sebaceous glands. Some animals, such as the skunk, have the power of ejecting the secretion, which is most foul-smelling, some distance over their enemy.

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[1] Another classification of the Carnivora is as follows:—

(1) *Creodonta.* Scaphoid and lunar of carpus separate. Extinct.

(2) *Fissipedia.* Scaphoid fused with lunar. Toes separate = Ursidæ, Mustelidæ, Canidæ, Felidæ, Viverridæ, &c.

(3) *Pinnipedia.* Limbs as paddles. Toes webbed.

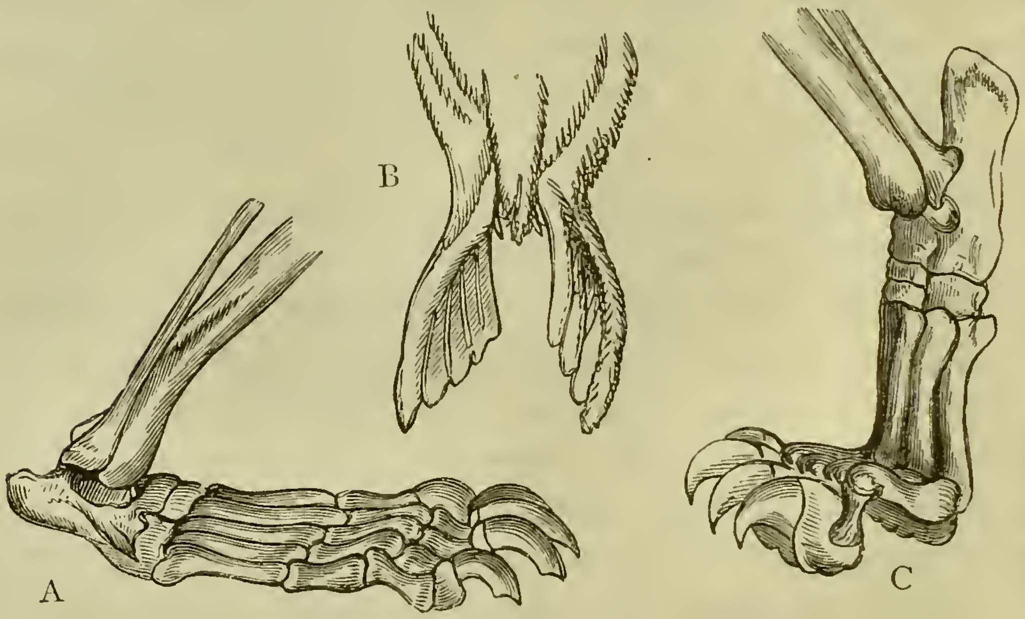

FIG. 251.—FEET OF CARNIVORA.

A, Plantigrade foot (Bear); B, Pinnigrade foot (Seal); C, Digitigrade foot (Lion). (Nicholson.)

The Mustelidæ are of considerable economic importance, as many of them are most injurious. We may here mention the Polecat (*Putorius fœtidus*), the Stoat (*P. erminea*), the Weasel (*P. vulgaris*) the Marten (*Martes sylvatica*), and the Otter (*Lutra vulgaris*), as being generally abundant in Britain, and also the Ferret (*P. furo*), which is said by some to be a native of Africa, but which may have been derived from the polecat.

The *Weasel* (*P. vulgaris*) is a small elongate animal about eight inches long with a tail about two inches long. It is brown above and with a white belly. The body is very slender and almost snake-like, the legs very short, and the head somewhat larger than the diameter of the trunk. It has a similar fur winter and summer. The weasel is extremely active in habits, and may be seen often with its family hunting along river-banks and dykes, going in and out of the water-voles' burrows. Their food consists of voles, rats, mice, lizards, snakes, frogs, and eggs. It is said that the weasel carries the egg it has taken under its chin. They do an immense amount of good in destroying voles, both in winter and summer. On the other hand, they sometimes take fowls' eggs and do other damage in poultry-houses of a night, whilst not a few game eggs are destroyed, and even young birds. Weasels often migrate in numbers from place to place, especially to where field-voles are in abundance. They breed in spring, sometimes having two litters. On the whole, they do more good than harm.

The *Marten* (*Martes sylvatica*).—Only one marten is found in Britain; it is of a rich dark-brown colour above and reddish-grey fur beneath, with a yellow or orange breast-spot, and a beautiful bushy tail. It was never very common in Britain, and is now very rare. Its skin always was, as it is now, of considerable value. Occasionally we hear of specimens being taken in various parts of the country.

The *Stoat* or *Ermine* (*P. erminea*) is found in fields and hedgerows near woods and in rabbit-warrens. It is about twelve inches long with a tail four inches in length, and has a slender body. In summer it is yellowish-brown with white belly, the tail tipped with black; in winter the fur becomes white except the tip of the tail, which remains jet-black. In Britain they seldom become beautifully pure white as they do in colder regions. Stoats hunt at night, feeding upon rats, mice, rabbits, and birds, and they sometimes commit havoc in poultry-yards. Like the weasel, however, they do good as well as harm.

The *Polecat* (*P. fœtidus*) or Foumart is much larger than the stoat, dark shining brown with yellow wool, and short tail compared with other Mustelidæ. Unfortunately this animal, owing to its unnecessary persecution, has become now very rare; still there are some places, notably in Wales, where we may still often see it in the winter. In those admirable articles on British Mammals in the 'Zoologist' (1891), Mr Harting tells us that twenty years ago it was comparatively common in most of the big woods in the home counties and within a very few miles of London. It lives in rabbit-warrens, hollow trees, &c., in the open country, and feeds upon field- and water-voles, rabbits, and birds. Eels form one of its favourite dishes. In winter the polecats come nearer habitations, taking up their quarters in wood-stacks, &c., from whence they come out and suck the eggs in fowl-houses, and even attack the birds themselves. The polecat's work in a hen-house can always be told by the eggs being sucked without being broken. From four to six young are born in May and June; the young are blind, and cannot see for a month. Gestation lasts six weeks. There is no doubt but that the polecat is the ancestor of the ferret: one cannot distinguish between the two on examining the skeleton. Instead of ruthlessly destroying the polecat, gamekeepers would do far more good by crossing them with the ferret, for no better workers than this cross can be found.

The *Otter* (*Lutra vulgaris*) is still widely distributed. A full-grown dog-otter may reach thirty-four inches in length, with about eighteen to twenty inches of tail. Its fur is smooth, dark shining brown. The body is more or less flattened, as also is the pointed tail. The short legs end in partially webbed feet, and the ears are covered with flaps of skin. Its whole structure is adapted to a semi-aquatic life. Otters inhabit the banks of rivers and lakes, where they feed upon fish, water-rats, frogs, insects, and even water-birds. They are not nearly so destructive to fine fish as is generally supposed, for they in preference take eels, roach, bream, and even jack.

The *Badger* (*Meles taxus*) is still fairly common in Britain, although not often seen on account of its strict nocturnal habits. In length some badgers reach over three feet, and weigh as much as thirty pounds. The head is white, with a broad black stripe on each side widening out towards the ears. The eyes are small, and the snout tapers somewhat to a point. The very loose skin is clothed with short fur and long greyish-brown hairs; throat, under parts, inside of leg, and feet black. The tail is short and bushy, yellowish-brown in colour, and about six inches long. The badger lives in huge burrows in the earth, with several openings, often twenty-five or thirty yards apart; these dwellings are made in the thickest woods some way from man's habitations. They sometimes use fox's "earths" for their burrows, and live in harmony with "Reynard." They often stay in their burrows for days at a time in winter, but do not actually hibernate. There are usually two large chambers in the burrows, the chamber in which the litter is found being lined with dry grass and leaves. The badger is not, as is generally supposed, a solitary animal, but where it is not disturbed it is social. Charles St John counted seven together at one time on the shores of Loch Ness.[1] The badger closes the entrance to its earth in winter when the weather is cold, but soon comes out when the temperature gets warmer. The young are usually four in number, being blind at birth and for nine days or so after. The diet of the badger is very varied; they take both animal and vegetable food. Roots of various kinds, nuts, leaves, grass, fungi, snails, slugs, worms, insects and their larvæ, frogs, snakes, birds' eggs and young ground-birds, mice, small rabbits, and even hedgehogs, are devoured by them. They certainly do some damage to game, but in nowise interfere with foxes, as is sometimes supposed. On the other hand, they do good by destroying many vermin, and therefore should not be destroyed, as has been too often the case in the past. They are particularly fond of wasp-grubs, and destroy great numbers of nests during the summer, a habit which alone should atone for the slight loss they may occasion in game and rabbits. The period of gestation seems to be very variable, some going as long as fifteen months, others only nine months: they evidently have the power of suspending gestation. The lower jaw is remarkable for being closely united to the upper jaw, by the glenoid cavity of the latter bending round the condyle of the former.

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[1] 'Wild Sports and Natural History of the Highlands.'

CANIDÆ (DOGS, FOXES, ETC.)

The Canidæ have pointed heads, smooth tongue, and non-retractile claws. The front feet have five toes, the hind only four. Two or three of the molars on each side are tuberculated. The only two species to be considered are the Fox (*Canis vulpes*) and the Dog (*C. familiaris*). The Dogs and Wolves have round or oblique pupils to the eyes; the Foxes have the pupil slit-like.

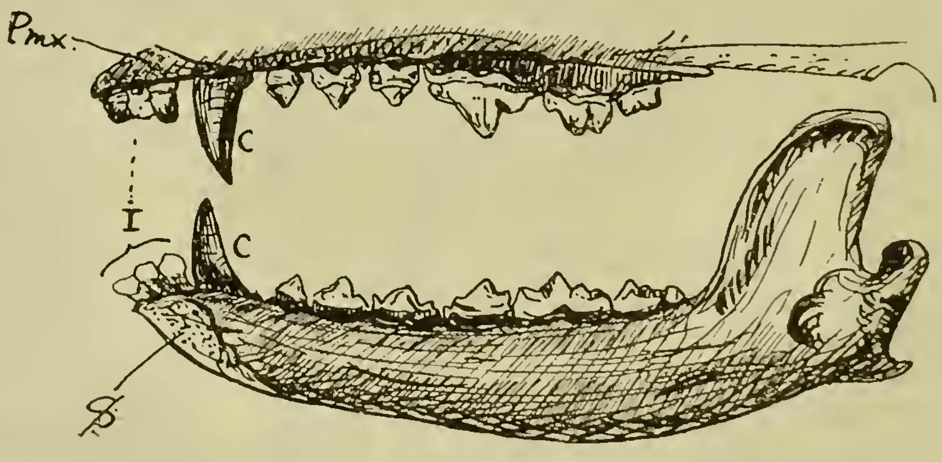

FIG. 252.—TEETH OF DOG, AND JAWS.
I, Incisors; *C*, canines; *S*, symphysis; *Pmx*, premaxillary bone.

The *Fox* (*Canis vulpes*) is too well known to need description. It partly lives underground, not only in an "earth" formed by itself, but in those formed by other animals, such as the rabbit and badger. In cold clay soils the fox will lie above ground under old roots of trees, in hollow trees, amongst scrub and gorse, and under the shelter of some ledge of rock along a cliff.

Mountain and moorland foxes lie out curled up in the heather and make no earth. The fox breeds in winter, the period of gestation lasting two months. They litter at the end of March and in April. Only one litter is produced in the year; from three to six cubs are generally brought forth. Like puppies, the cubs are blind for from nine to ten days; they mature in a year and a half, and may live for fourteen years. Foxes are supposed to do much damage by destroying game, poultry, hares, &c.; at the same time we must remember that they destroy numbers of voles, rabbits, and many of the larger noxious insect-grubs. The fox does quite as much good as harm, if not more, and thus should be preserved, even if we do not choose to consider its great sporting value. We may suffer severely, of course, if one foolishly leaves fowls without protection.

With regard to the dog, we do not know its origin. All existing wild dogs, such as the Australian Dingo (*C. dingo*) and the wild New Zealand dog, are sometimes supposed to be varieties of the so-called *Canis familiaris*. The dog, then, is only known in its domesticated state. There is some probability that the Wolf (*C. lupus*) may have been the ancestor of some of our breeds.

FELIDÆ OR CATS.

The cat family all have short jaws and very strong masticatory muscles, hence the head is short and rounded. The molar and premolar teeth are fewer in number than in any other Carnivora; they are all cutting teeth except the last molar of the upper jaw, which is tuberculate. The upper carnassial has three cutting lobes, the lower only two. The dental formula for the Cat family is the following:—

$$i\,\frac{3-3}{3-3};\ c\,\frac{1-1}{1-1};\ pm\,\frac{3-3}{2-2};\ m\,\frac{1-1}{1-1}=30.$$

The tongue is roughened owing to a number of backwardly projecting horny papillæ. The fore-feet have five, the hind four toes, armed with claws, which are retractile. When not in use these claws (fig. 253, A) are drawn back by means of ligaments (*a* and *b*) into sheaths (*s*), so as not to be unnecessarily worn down. All the Felidæ are extremely active, and have a very flexible backbone. They are mainly nocturnal in habits, catching their prey by springing upon it; many of the lighter-built Felidæ climb well.

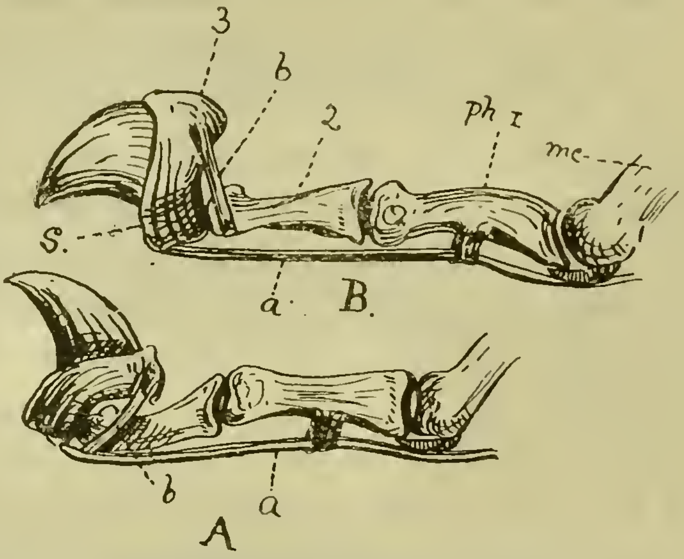

FIG. 253.—BONES OF TOE OF CAT—A, with retracted, B, with extended claw.

a, Tendon of extensor muscle; *b*, retractor ligament; *mc*, metacarpal; *ph* (1, 2, and 3), 1st to 3rd phalanges; *s*, bony sheath into which claw fits. (From Brit. Mus. Cat.)

One wild species occurs in Britain, but only in the north, especially Scotland, and the writer has seen it on Cader Idris in Wales—namely, the Wild Cat (*Felix catus*). The domestic cat is descended from the Nubian Cat (*F. maniculata*), a native of the Sudan and Nubia.

RODENTIA or GNAWERS.[1]

The order Rodentia contains the Mice, Rats, Squirrels, Rabbits, and Hares. These are sometimes called "Glires." The

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[1] The Rodentia are also placed in the order *Trogontia* of Haeckel; the two other sub-orders are the *Tillodontia* and *Typotheria*, formed for certain Tertiary species.

Rodents are characterised by having two long curved incisor teeth in each jaw (fig. 254, *i*); the crowns of these are continually being worn down, whilst growth as rapidly takes place at their roots. These teeth are employed in gnawing, and are more readily worn down behind than in front, so that they always present a sharp edge. This is due to the front having a plate of very hard enamel, whilst the back is composed of soft dentine. The lower jaw has never more than two incisors, the upper may have four. Canines are never present; the molars and premolars are seldom more than four in number on each side of the jaw. The molars have flat crowns, the enamelled surfaces being in transverse ridges running across the teeth. The hind-feet are longer than the fore-feet, thus giving them the curious springing gait; the feet have usually five toes furnished with claws, but they may be reduced to four on each foot. The eyes are large and directed laterally. The brain has no convolutions, being nearly smooth. Many rodents have curious lateral "cheek-pouches" in which food can be stored for some little time; when this food is required, the animal presses the pouches with its fore-feet. Most rodents are small animals, and feed upon vegetation. They are endowed with great reproductive faculties. The fœtus is enclosed in a deciduate dis-

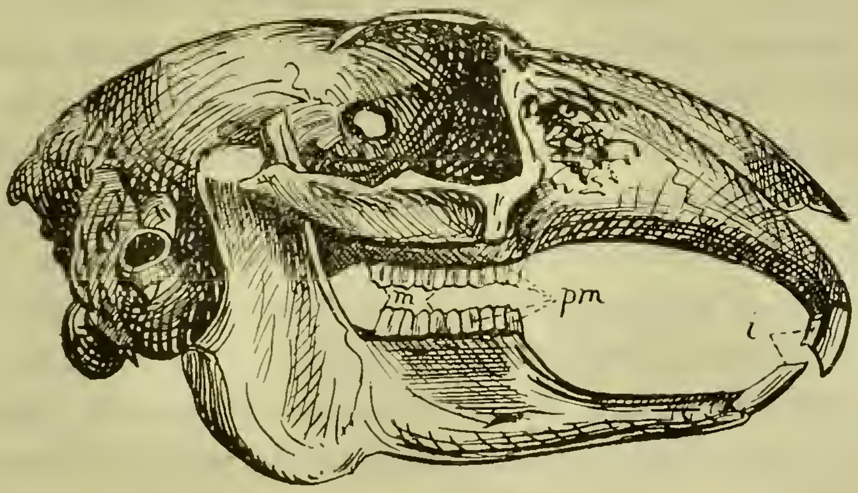

FIG. 254.—HEAD OF RODENT. THE HARE (*Lepus europæus*).
i, incisors; *pm*, premolars; *m*, molars.

coidal placenta. In the male the testes are temporarily placed in the scrotum, at other times they lie in the abdomen.

The chief families are the *Muridæ* (Rats and Mice), the *Arvicolidæ* (Voles), the *Leporidæ* (Hares and Rabbits), the *Cavidæ* (Guinea-pigs), the *Castoridæ* (Beavers), and the *Myoxidæ* (Dormice). All we need consider are the Mice, Rats, Voles, and Rabbits.

MURIDÆ, OR RATS AND MICE.

In this family the tail is long as a rule, and the body is long and narrowish. Hind-legs longer than the fore-legs. Head pointed. The back molars possess a tuberculate crown, entirely covered with enamel. External ears clearly seen. The genus *Mus* (Rats and Mice) have long, scaly, ringed tails.

Three species of Rats are found in Britain—namely, the Black Rat (*Mus rattus*), the Brown Rat (*M. decumanus*), and the Irish Rat (*M. hibernicus*) ; this last species, told by the diamond-shape patch of white in front, is only found in Ireland and the Outer Hebrides. The Black Rat only is indigenous to Europe (unless *M. hibernicus* is really a distinct indigenous species) ; it is smaller than the common brown rat, which came over to Europe in the eighteenth century. It was imported into Britain in shipping, and is now spread all over the world. It may also have entered Europe from Asia by migrating into Russia. In any case, it has increased with alarming rapidity, and has quite driven out the indigenous black rat. The black rat is smaller and much darker than *M. decumanus*, which has a dusky-grey belly and a longer tail. Here and there specimens are still seen, the writer having trapped it in Lundy Island.

The Rats live upon all manner of substances, and are noxious in many ways,—a great nuisance indoors, a veritable pest in poultry-yards and amongst corn, whilst they also distribute the trichinosis amongst pigs, a disease which rats are very subject to, and still more, through their fleas, plague.

A fourth species, *Mus alexandrinus*, is sometimes found in dockyards, &c., having come over in ships from Egypt, but I am not aware that it is established in Britain.

Three species of Mice are common in Britain—namely, the Common Mouse (*M. musculus*), the Wood-Mouse (*M. sylvaticus*), and the Harvest-Mouse (*M. messorius*).

The *Long-tailed Field-Mouse* or *Wood-Mouse* (*M. sylvaticus*).—This is the largest of our mice belonging to the genus *Mus*. It can be told from the Common Mouse (*M. musculus*) by its warmer-coloured fur, by the greater size of the ears and length of the hind-legs, by the large, very prominent eyes, and by the elongated tail: it is between three and four inches in length, the tail being another three and a half inches long. *M. sylvaticus* is yellowish-brown with a greyish tinge, and white beneath with a patch of fawn between the fore-legs; the feet and fore-legs are pure white up to the carpus; the posterior feet and legs also white below, a white streak running up to the under surface of the body. The long flexible tail is dusky-brown above, white below. This mouse is a great pest to both farmer and gardener. It eats corn, and works along the rows of peas in the garden, whilst nuts, roots, clover, and carrots all fall to its bill of fare. These mice store up immense quantities of food for the winter, but do not hibernate. Wood Mice have been trapped in the hardest weather, when they come out to feed upon the bark of small trees. This species was one of the two that caused so much harm to the trees in the Forest of Dean in 1813. It may also take young birds, and I have found the remains of numerous Coleoptera in their stomachs, especially Carabidæ. Their burrows are found in banks, old walls, hedges around gardens and fields, and at harvest-time in the fields. They commence to breed in March, and have four litters, the number of young varying from six to nine. The young are said by Gilbert White and Barrington to stick most tenaciously to the teats of the mother when they are frightened.

The *Harvest-Mouse* (*M. messorius* = *minutus*).—This mouse is bright sandy-yellow, brightest in colour towards the tail, and white beneath; the sides of the head are orange. The colour, however, varies a good deal, but is always brightest in the female sex. The feet are long and delicate, and covered with fine yellowish hairs in front and white at the sides. Tail scantily clothed with hair. Length, as a rule, two and a half inches; tail two inches. The period of gestation is said to be three weeks; the young vary from five to eight. This species builds a beautiful nest lined with fine hair and grass, said to be split up by the animal's teeth. The nests are often no larger than an orange, and sometimes quite round. This breeding-nest is much like that of a bird. A winter nest is also formed, where they pass the cold months of the year, in stacks, &c. The favourite localities are amongst reeds, long grass, and low shrubs, where the nest is often placed some way off the ground. It is no unusual thing for *M. messorius* to take the nest of a warbler and build its own in and over it. They may sometimes be found in wheat- and barley-fields, but never in any great number. These mice feed on corn and various seeds, also flies and other insects, and they are known to eat the buds of gooseberries and currants. Hazel-buds are also eaten.

The *Common Mouse* (*M. musculus*) need not be referred to, being well known. It is chiefly this species that we find so abundantly in corn-fields, and not *M. messorius*, as is generally supposed.

ARVICOLIDÆ OR VOLES.

These can be told from the true Rats and Mice by the more solid body, thick head, and blunt snout, by the absence of external ears, which are covered in fur, and by scales being found wanting on the tail, which may be partly hairy.

There are three common species—namely, the Water-Vole (*Arvicola amphibius*), the Bank-Vole (*A. glareolus*), and the Field-Vole (*A. agrestis*). None of these are found in Ireland.

The *Field-Vole* (*A. agrestis*), sometimes called the short-tailed field-mouse, is a small vole with dark-brownish back and grey belly. This vole lives in colonies, preferring low-lying pastures, where it burrows into the ground. This species is most prolific, having often four litters in the year, each consisting of eight to ten young. Field Voles are frequently most destructive in pasture-land, also destroying the bark of trees.

The *Water-Vole* or *Water-Rat* (*A. amphibia*) lives along the banks of streams and in damp meadows, tunnelling branched passages into the soil. It is blackish-brown on the back, with a greyish-brown belly, and is often very destructive to grass-land and corn and "clamped" roots. This vole takes the eggs of poultry, and damages the banks of rivers, canals, and dykes often to an alarming extent.

The *Bank Vole* (*A. glareola*), a brownish-red species with pure white breast, belly, and feet, occurs chiefly in forest tracks. Unlike the field-vole, the tail is very long, there being twenty-three caudal vertebræ; and the ears are also longer than those of the field-vole, coming above the fur. It is from three and a half to four inches long, the tail being an inch and three-quarters. *A. glareolus* may be found in sheltered hedge-banks and ivy-clad tree-stumps, and amongst the exposed roots of trees in banks.

Plagues of Voles.—In 1891 there was a great plague of field-voles (*A. agrestis*) in South Scotland. In Roxburgh and Dumfries alone over 90,000 acres were more or less affected. They first increased in 1890, overran the boggy and rough land, and then spread everywhere, damaging grass, heather, and trees, and carrying ruin before them. What had preceded this plague? Constant war with trap and gun upon the gamekeepers' so-called "vermin." The Scottish farmers had to suffer for the ignorance of the gamekeepers, who had killed off the natural enemies of the voles—namely, the hawks, owls, crows, weasels, polecats, &c.

A still more serious outbreak of voles (*A. arvalis*) occurred in Thessaly in 1892, which threatened to destroy the whole corn crop of the district; but, thanks to Professor Loeffler, the voles seem to have been exterminated by inoculation on a large scale with his *bacilli typhi murians.* At present various "virus" are on the market for killing Rats, Mice, and Voles. The writer has not found these to be always of value.

Family LEPORIDÆ (RABBITS AND HARES).

These rodents can be told by their possessing two small incisors in the upper jaw (fig. 254), just behind the two large frontal ones, so that the dental formula runs thus:—

$$i\,\frac{2-2}{1-1};\ c\,\frac{0-0}{0-0};\ pm\,\frac{3-3}{2-2};\ m\,\frac{3-3}{3-3}=28.$$

The upper lip is cleft and the back teeth have folds of enamel. The fore-legs are much shorter than the hind-limbs, and have only four toes, while the tail is short and erect.

The *Rabbit* (*Lepus caniculus*) breeds with great rapidity; the young are blind and hairless at birth. From five to eight families are produced in the year, and often there are six young at a time. They commence to breed when only six months old. The burrows, which are in large companies (warrens), can be formed in any soil not too stiff. The rabbit will flourish everywhere in temperate and sub-tropical regions, and is often, as we see in Australia, a terrible scourge. This, again, has been brought about by the mad slaughter of weasels, stoats, and rapacious birds.

The *Hare* (*L. timidus*), on the other hand, litters in the open, the young being born in a more advanced stage than in the rabbit, and with open eyes. They do not breed as rapidly as the rabbit, seldom more than four times a-year, producing two to four young (leverets). The common hare is found all over Europe except Sweden and Norway. Hares are often destructive to crops, especially cabbage, carrots, turnips, and rape. They will eat almost any green stuff. It is chiefly in gardens that they do harm, but they can easily, like rabbits, be kept out by wire.

INSECTIVORA (INSECTIVOROUS MAMMALS).

All the Insectivora are small mammals, very like rodents in appearance, but have not the rodent incisors, and have, on the other hand, distinct clavicles (fig. 255 B, *cl*), which are absent in the gnawing mammals. The teeth are very variable: the molars are always serrated with small pointed cusps, perfectly adapted for crushing their insect food; there are never less than two pairs of lower incisors. Insectivora have five toes, armed with claws, to each foot. They are plantigrade. The snout is slender and sensitive, being used as an organ of touch. Most of this order are small nocturnal mammals, many being subterranean in habit. The placenta is deciduate and discoidal. They are all more or less beneficial, feeding upon ground-insects, worms, and snails. A few feed upon small birds and mammals and vegetation. In most the eyes are badly developed, in some they are scarcely of any use.

The families of economic importance to us are the Moles (*Talpidæ*), the Shrew-Mice (*Soricidæ*), and the Hedgehogs (*Erinaceidæ*).

Family TALPIDÆ.

Body covered with a thick soft fur; feet adapted for digging in the earth, with large claws; eyes, which are present deep in the fur, more or less useful for purposes of vision—they can distinguish the light from darkness, if nothing else; the fore-legs are short, broad, and spade-like, and the palms are turned backwards. The British species is *Talpa europæa*, which has a beautiful shiny black fur. The mole may be found nearly everywhere, unless the soil is very heavy; its presence may be detected by the heaps of earth it throws up out of its tunnels in the ground. Light soils are preferred by it, especially where there is plenty of humus, but it may be found even along chalk downs. We know of one place where there is not more than two inches of humus over the chalk, and where moles are abundant. The nest is placed under a heap of earth, and consists of a large round space lined with vegetable matter ; this central space is surrounded by other smaller chambers and passages. From the nest there runs a tunnel to the place where the insects, such as wireworm, abound ; the walls of this tunnel are firm and compressed. The chains of mole-hills and the subterranean passages having fallen in are certain indications of the mole's feeding-ground : its passage to this area is marked by a depression in the soil. There are two separate chambers for living and breeding in. The latter is often lined with fur. The depth of the tunnels varies with the season, according as to whether the wireworms and earthworms are near the surface or deep down. The mole hunts winter and summer, and does inestimable good by devouring noxious grubs. Some authorities say they store up earthworms in deep firm-walled depressions for winter food and food for the young. The young moles are born in June and July ; the number of each litter varies from five to seven. Not only do they hunt underground, but they may often be found tracking the earth-

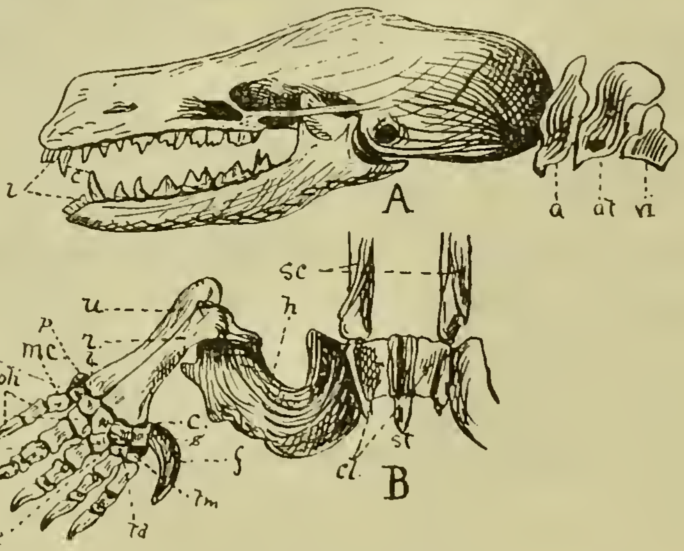

Fig. 255.—a, Skull, and b, Shoulder Girdle of Mole.

c, Carpus ; *cl*, clavicle ; *f*, falciform bone ; *h*, humerus ; *mc*, metacarpus ; *ph*, phalanges ; *r*, radius ; *u*, ulna ; *sc*, scapula ; *st*, sternum ; *i*, incisors ; *c*, canines ; *a*, atlas ; *at*, axis ; *vi*, third cervical. (After Thomas.) (Brit. Mus. Cat.)

worm above ground. In Ireland *Talpa europæa* is unknown, nor is it seen in the Western Islands of Scotland. They may be a nuisance in grass-land and corn-fields at harvest-time, but should then be trapped alive and put where they can do much good, as long as they are not allowed to increase unduly. But is it certain that they do any harm? Surely by tunnelling the earth they help surface drainage; surely the mould they bring up, spread upon the land, would act as a beneficial top-dressing; and what of the countless hordes of wireworm and leather-jackets they destroy?

The Soricidæ or Shrew-Mice

are all small mouse-like animals with soft fur, well-developed eyes, and external ears, and with a more or less pointed snout. Shrews live in subterranean passages, where they devour noxious grubs. They do not, it seems, make their own passages, but live in those formed by voles. All the Shrews have a peculiar smell, coming from two sebaceous glands near the anus.

Three species are found in plenty in Britain—the Common Shrew (*Sorex vulgaris*), the Little Shrew (*S. pygmæus*), and the Water-Shrew (*S. fodiens*). The last mentioned is quite black, and although beneficial on land, is said to be most harmful to fish-breeding, living upon the small fry.

The Erinaceidæ or Hedgehogs

are represented by one species in Europe—namely, *E. europæus*—that lives upon grass-snakes, adders, frogs, snails, and various grubs, voles, poultry and game eggs, and sometimes vegetation. They hunt only of a night, rolling up into a ball when attacked, and are thus protected by the prickly spines on the upper surface of the body. The Hedgehog passes the winter in a semi-dormant state, but sometimes comes out at that time of year. From three to four young are born in May: they are pinky white, with white quills, and both eyes and ears are

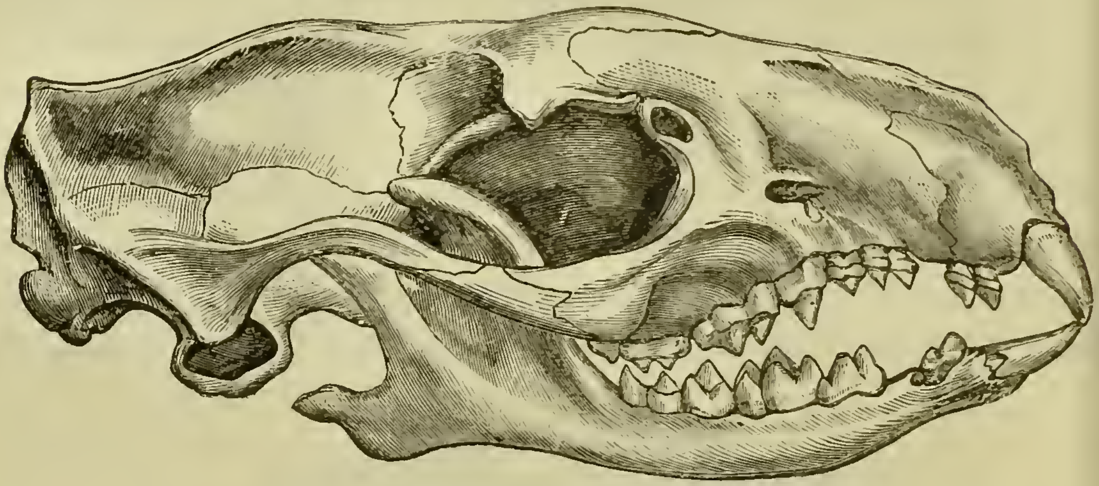

FIG. 256.—SKULL OF HEDGEHOG (*Erinaceus europæus*). (Nicholson.)

closed. They are produced and kept in a nest of moss, covered with leaves. In many respects the hedgehog is injurious, but it also does good in destroying vermin.

CHIROPTERA or BATS.

The Bats, which are insectivorous mammals, are characterised by the peculiarly modified forearms, adapted to form the wings. The digits of the fore-limb are enormously elongated, except the pollex. These fingers are united by a thin membrane called the "patagium" (fig. 257, *P*), which is also extended between the fore and hind limbs and united to the sides of the body. This expanded membrane is used for flight. The pollex and first finger of the fore-limb may have a claw, but the others are destitute of them. The hind-digits have each a long nail. Bats have teeth of three kinds, and in all the canines are well developed. The molars in the insectivorous bats are always sharp pointed; in the foreign fruit-eating bats they are tuberculate. The bones are never hollow as in birds. Two mammæ are placed upon the chest. The body is covered with hair, and

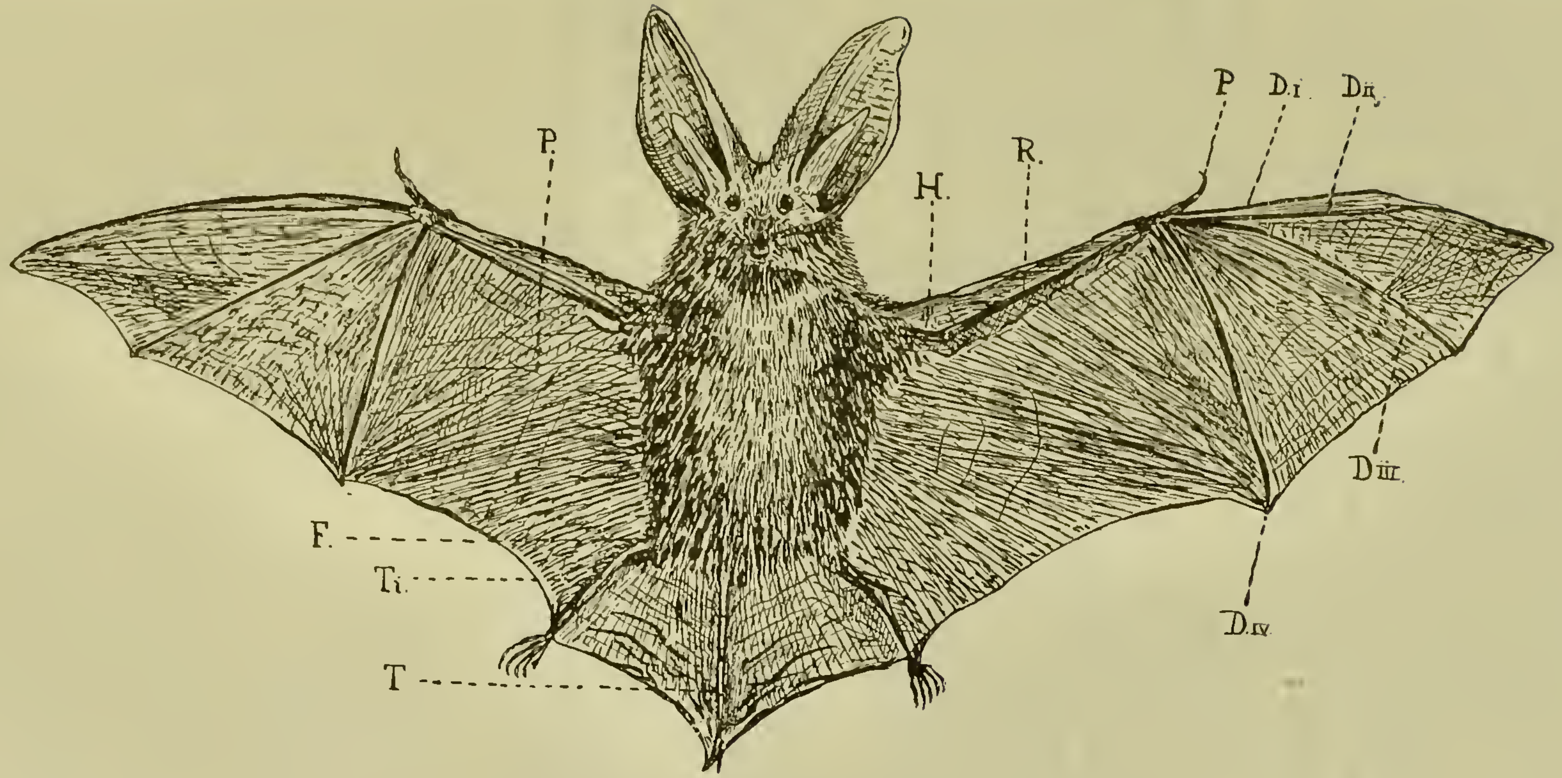

FIG. 257.—LONG-EARED BAT (*Plecotus auritus*). (½ nat. size.)

P, Patagium; *H*, humerus; *R*, radius; *P*, pollex; *D*i—*D*iv, phalanges; *F*, femur; *Ti*, tibia; *T*, tail.

the ears may be large and sensitive. The tail (*T*) is sometimes included in the patagium, which stretches between the hind-limbs. Bats are either nocturnal or crepuscular, and therefore the eyes are small, the sense of touch being correspondingly developed. They pass the day hanging up in hollow trees, amongst masonry, in caves and the crevices of rocks. Only insectivorous bats (*Insectivora*) occur in Europe; the *Frugivora* occur in Australia, Java, Asia, &c.

We have at least seventeen species in England, the commonest being the Pipistrelle (*Vespertilio pipistrella*), the Long-eared Bat (*Plecotus auritus*) (fig. 225), the Large Noctule (*V. noctula*), and two Horseshoe Bats (*Rhinolophus ferrum-equinum* and *hipposideros*), which have a curious leaf-like structure attached to the nose, of a sensory nature. These bats feed chiefly on moths, and thus prevent large numbers of caterpillars from attacking our crops.

The other orders of Mammalia are not of any special importance to us, and thus need not be referred to in this text-book.

The Animal Kingdom culminates in the order **Primates**, which includes the *Quadrumana* or Monkeys and Lemurs, and the *Bimana* or Anthropoid Apes and Man.

APPENDIX

APPENDIX I.

THE PREVENTION AND TREATMENT OF VERMICEOUS DISEASES.

ALTHOUGH we have said in chapter v. that some worms (Anguillulidæ) occasion considerable harm to certain crops, yet it is amongst our stock that their ravages are mostly felt, especially in sheep, cattle, and horses. As the loss that many worms are accountable for often reaches very serious dimensions, a few general notes on the prevention and treatment of these parasitic diseases may not be out of place here, after having dealt with their economic history in preceding chapters. The three most important groups of the parasitic worms are the Tapeworms, Round- or Thread-worms, and Flukes. Tapeworms often cause severe diseases in animals and man (so called *Tæniosis*). When we know the life-history of a species it is usually easy to prevent the increase, if the trouble is taken to do so; but where we are ignorant of the various stages and habitats of the pests, remedies only lie in our power. As pointed out in chapter iv., most tapeworms have two distinct hosts —one in which the adult sexual tapeworm lives in the intestines, another in which the asexual cyst or bladder-worm takes up its abode. The cysts are usually found in carnivorous and omnivorous animals, in the various organs and internal membranes. Each cyst may give rise to one or hundreds of adult worms, in another animal, on being eaten. By the destruction of these cystic parts the tapeworm stage is prevented, and the tæniosis is stopped from spreading. For instance, if all the heads of "pothery" or "sturdy" sheep are destroyed (and sometimes in lumbar-gid the spinal cord) with the cœnuri in them, so many hundreds of *Tænia cœnurus*, one of the dog tapeworms, are destroyed. Again, if the diseased pork called "measly pork" is not eaten insufficiently cooked by human beings, the dreaded human tapeworm, *T. solium*, is prevented, and the same with "measly" beef.

The destruction of all parts containing the cysts or water-bags should be carefully carried out, instead of throwing the same to dogs, or being used even as human food.

The ova and embryos that form the hydatid stages or cysts are obtained in a great number of cases from polluted drinking-water. The eggs passed out with the sexual tapeworm, and thus out of the host, are often left upon the ground, and get carried by rain to runnels, ditches, dykes, and rivers. Yet many are taken off the ground direct by herbivorous animals. Sometimes whole proglottides voided out in the dung are eaten, and then the animal is invaded, if it be the proper host, with hundreds of small cysts, as seen in *Cysticercus cellulosæ* in pigs. We must bear in mind that we cannot get rid of these cysts when once they have taken up their rendezvous in the organs, except in the isolated case of *Multiplex multiplex*, which may sometimes, if a single cyst only exists, be extracted from the sheep's brain by trephining. It is therefore very essential to prevent the ova of cestodes from entering an animal. To do this we must endeavour to keep our stock free from these worms (and other parasites). When they are noticed by such symptoms as thinness, capricious appetite, irritation in the lumbar regions, and the presence of proglottides in the excreta, the patient should be shut up, well dosed, and all excrement, with the expelled proglottides and scolices, burnt. We must bear in mind that as long as the scolex remains the cestode can continue to grow, thus necessitating the certain expulsion of this budding area.

In regard to tænicides, great numbers of substances have been experimented with, and many are more or less successful. Before dosing, the patient should be given no solid food for at least twelve hours previously, but a small quantity of soft food only. A mild dose of castor-oil should also be given beforehand. The most certain drugs are areca-nut, male fern, calomel, pomegranate bark, and sulphuret of calcium. Perhaps the best is a mixture of areca-nut and male shield-fern powders in the proportion of 2 grains of areca-nut to every pound-weight of the dog, with 15 minims (drops) of male shield-fern extract. This tænifuge should be given in sweet milk, and is best followed next morning with a mild dose of castor-oil. As a rule, two doses of the powders are necessary. Æthereal extracts of male shield-fern in 2-grain to 6-grain doses also brings away the worms. Similar drugs may be used for poultry in varying doses. But for sheep, kamala in 10-grain doses has met with most success. In poultry I have obtained excellent results with the extract of male fern, about 10 drops administered in salad-oil.

Nematode or round-worms are little affected by the above, at least the majority of species. The round-worms may or may not have two distinct hosts. Such groups as the Trichinæ live in two different animals or in different parts of the same animal. The asexual forms live in the connective-tissue organs, and in the blood-vessels, &c. ; the sexual forms in the intestines, the air-passages, and a few beneath the skin. The majority of Nematodes pass their eggs out in the host's dung, the worms coming away when their full complement of eggs are laid. These ova lie about upon the ground, get carried into the water, and are thus taken up again with food and drink. Some undergo a slight development outside the host upon the damp ground and vegetation ; and possibly some few may live in a secondary host, such as earthworms, snails, insects, &c. Some are carried by biting flies (Filariæ and Mosquitoes).

The well-known disease, trichinosis in pigs, rats, and men, is distributed chiefly by rats, and through them it is given to pigs, and from the latter to man. Here again the knowledge of the life-history helps us, for by stopping the common practice of giving dead rats to the pigs, we shall tend to check a disease which in human beings may be attended with fatal results. The destruction of rats is most necessary.

Some pastures are known to be impregnated with certain diseases, such, for instance, as lung-worm or husk, and the worms producing parasitic gastritis. When this is known to be the case, it is well to keep the animal subject to the disease off the land for some time, feeding it down in the meanwhile with other stock that are not invaded by the particular kind of parasite we wish to destroy. In the red intestinal worms, the armed sclerostomes, in horses, we can employ this way of clearing the paddocks by grazing sheep on them for some time : these animals, feeding close and making the land obnoxious by their excreta, destroy the majority of the eggs passed out in the horses' dung, and are not themselves invaded by the equine parasites. A large number of round-worms live in the intestines of all animals, and as the ova are passed out in the dung, it is very essential in an outbreak of these nematodes to see that the diseased animals, such as horses, are boxed and all the excrement burnt, whilst the meadows should be kept free from the hosts, and if the disease is not an ovine one, dressed with salt and fed down by sheep. Diseases, such as husk, are spread by the embryos being brought up in the mucus from the air-passages ; these germs are scattered about upon the ground, and thus sow the seeds of disease for numbers of other lambs and sheep. When that spasmodic cough so characteristic of "hoose" is heard, it is surely advisable to remove the animal, and so prevent it from contaminating the ground.

Similar remarks apply to gapes in poultry. The ground becomes fouled with the ova released from the bodies of the coughed-up syngami, to such an extent that it is not possible to go on successfully breeding birds on the same land for any length of time. Runs and breeding-places should be dressed with gas-lime, so as to destroy the ova and embryos, and chicks ought to be kept far from the stock-birds. Unfortunately wild birds suffer from gapes, so that we shall constantly get fresh infestations, but we can prevent epidemics.

Speaking generally, we can prevent nematode diseases by isolating the sufferers, burning their excrement, and removing to fresh land, thus allowing the old land to have a rest, or by substituting other kinds of stock until the land becomes once more clean. It is very doubtful if any dressings can be applied to grass-land, as nothing will touch the ova or larvæ that will not burn the grass as well. Lastly, attention to the water-supply should not fail to be given during and after an epizootic attack on the farm. For destroying round intestinal worms, such as the ascarides and oxyures, the drug called santonine may be successfully used. It should be preceded by a purgative and absence of food for some six to twelve hours. For horses santonine is used at the rate of 20-grain to 30-grain doses, one dose given in the morning, another of a night, followed by a purgative next morning. By far the most certain nematocide is thymol, given in 15-grain doses to horses morning and night, followed by a dose of castor-oil. Thymol can be dissolved in alcohol, and should be administered in warm sweet milk. In cases of armed sclerostome attack the drug is especially valuable, as it not only clears out the free red-worms (*S. equinum* and *S. tetracanthum*) but also destroys those encysted in the mucous membrane. Generally the two doses suffice, but it is best to follow with the same treatment next day. Dogs can only stand from 2 to 3 grains of thymol, and fowls, I find, only 1 to 2 grains, which soon removes the white thread-worms (*Heterakis*).

Those vermiceous pests that attack the air-tubes, such as the gape-worm in fowls and some of the lung-worms of sheep and calves, can be destroyed by tracheal injections of camphor and creosote; but as skilled labour has to be employed, and then only one of the three worms in the lamb is affected, the method is scarcely to be advised, in sheep. Fumigations with sulphur, &c., are equally unsatisfactory. All we can do is to keep the stock well fed, isolate the affected ones, and avoid foul pastures. In gapes, however, allowing a drop of camphorated or eucalyptus oil to run down the trachea is always satisfactory, and perhaps is the best way to treat birds when only a few are attacked; but when large numbers have gapes the use of the fumigating-box is advisable. Blowing into the box, with bellows, finely ground camphor and chalk causes the worms to relax their hold and the birds to cough, and so the nematodes are expectorated.

Flukes or trematodes are impossible to destroy, as far as our present knowledge goes, when once fairly housed in the bile-ducts and liver. Land along the edges of rivers and streams may be said to be generally liable to be infested with trematode germs, which, as pointed out previously, live in the water-snails (*Limnæus truncatulus*) during part of their early life. Certain meadows in which these molluscs abound are sure to affect the flock; such land should thus be fed to beasts which, although sometimes subject to trematodes, are not seriously affected. Attention should be paid to the molluscan hosts, hordes of which may be destroyed, when cleaning out the ditches and dykes, by casting lime over the mud brought out, when not only the primary host but the embryo flukes are killed. In all parasitic vermiceous diseases the strength of the host must be well maintained by good and rich feeding, so that the invaded animal can withstand the extra drain on its system. This and proper sanitary measures, the application of a few well-known vermifuges, and the destruction of diseased parts instead of giving them to dogs and other animals, are the main points in preventing the too persistent losses from vermiceous diseases.

In the case of infected food, which seldom now passes out of the markets in this country, thorough cooking destroys the cysts and germs of various diseases, the chances of infection being very slight. Water plays a prominent part in the distribution of these complaints, and where possible the purest spring-water only should be employed, for stock as well as for man, especially during and after an outbreak.

APPENDIX II.

THE PREVENTION AND DESTRUCTION OF INSECT PESTS.

To be able to cope with the numerous insect attacks which our fruit, vegetable, and other crops and stock suffer from, it is essential that we know certain entomological facts, and something of the life-histories and habits of those insects we wish to destroy. A knowledge of some of the simplest elements of entomology will enable us to understand the why and the wherefore of applying certain remedies in certain ways and at particular times. (*Vide* chapter vii.)

Certain insects are injurious in one stage only, others in two stages, and those with an incomplete life-history during their whole life-cycle, from the hatching of the egg onwards.—In the majority of groups it is the larva that does most harm, as in the wireworms or larvæ of the click beetles (*Elaters*), the leather-jackets or larvæ of the daddy-long-legs (*Tipulidæ*), the surface-larvæ or caterpillars of the dart-moths (*Noctuæ*), and the root-eating maggots, the larvæ of true flies (*Diptera*). There are, nevertheless, many exceptions to this general rule: for instance, both larva and adult of the cockchafers (*Melolonthidæ*) do damage; the larva as well as the imago of the flea-beetles (*Halticidæ*), the pea weevils (*Sitones*), the raspberry weevil (*Otiorhynchus*), and asparagus beetle (*Crioceris*) also cause considerable loss in our fields and gardens. In the case of flea-beetles and others the adults do most harm, the damage caused by the larvæ being of secondary importance. Those insects, such as plant-lice, which have an incomplete metamorphosis are destructive in all their stages. With the exception of this last group, the *larva, pupa, and adult have generally different habitats.* In some insects we can best get at the larva to destroy it, in very few the pupa, whilst many we can attack whilst in the adult phase. The egg masses of a few may be destroyed in winter. Thus the importance of knowing the life-histories of our insect and other pests.

Nearly every known plant is attacked by some insect.—Very often each species of insect has a particular food-plant: the onion fly only attacks the onion, the rust or carrot fly the carrot and parsnip, the American blight the apple and hawthorn (seldom the pear). More generally any member of the same family of plants is attacked by one species of insect; for example, the turnip flea infests all Cruciferæ alike. Some of our worst pests are general feeders, such as the wireworm and leather-jacket, which will feed off the roots of nearly all plants. Where we get one species feeding only off one particular plant or family of plants, we can do much to prevent their damage by judicious rotation in the garden and in field cultivation.

Three of the most important structural features to be considered in regard to insect eradication and prevention of their attacks are the structure of the mouth, the breathing apparatus, and the organs of sense.—There are three distinct types of mouth found in insects: the first is modified for *biting*, the second for *piercing*, the third for *sucking*. Insects provided with a biting mouth devour plant-tissue wholesale, both leaf, stem, and rootage being subject to their onslaughts. *Piercing-mouthed* insects have their mouth-parts drawn out into needle-shaped lancets enclosed in a tube formed by the upper and lower lips. These insects feed by plunging the proboscis *into* the leaf and drawing out the sap. *Sucking-mouthed* insects have a long, soft, coiled proboscis, and can do no harm. Lepidoptera have sucking mouths, but some few in Africa, &c., have the proboscis so hardened they attack fruit. This structure of the insect mouth is a point too often neglected by people anxious to destroy insects. Poisons such as arsenical washes are useless for piercing-mouthed insects such as plant-lice and bugs; on the other hand, poisons that will hold to the leaf will be taken in by leaf- and blossom-eating larvæ, and so destroy them. The plant-louse would plunge its beak through the poison before it used, and so escape its ill effects; to poison plant-lice we should have to poison the sap. How, then, can we destroy such pests? On examining any insect we shall observe (as pointed out in chapter vii.) at the sides of the body a number of oval or slit-like apertures: these are *breathing-pores* or *spiracles*. Insects do not breathe through their mouth, but through these respiratory openings. Varnish these over, and the insect will be asphyxiated. Plant-lice, &c., can be killed, then, by using some spray that will block up these breathing-pores:

soft-soap answers this purpose ; other substances, such as quassia, put in the wash, are of value, but are not essential for killing most aphides. Soft-soap also adheres to the aphides' skin, and is useful besides in fixing corrosives and poisons on the insect and foliage. The more soft-soap used, within certain limits, therefore, the better. Certain substances, as paraffin, corrode the skin of aphides. Mites, on the other hand, breathe cutaneously, and not through spiracles ; nicotine or soap washes have less effect on them.

On the head of an insect we have observed, besides the mouth, two kinds of eyes, simple and compound, and in front of the two large compound eyes a pair of jointed horn-like processes, the "feelers" or antennæ.—What are these feelers for ? They are sense organs : whether they serve for one or two or more sensory functions we do not know. One sense is certainly developed in them—namely, "smell." The sense of smell may also be seated in the jointed palpi attached to the two lower pairs of jaws. Insects have the sense of smell very acutely developed : they are attracted to their food-plant by its odour, both for feeding purposes and for oviposition. Plant three beds of carrots in your garden some distance apart : sow one thinly, so that you have no necessity to thin them out ; sow the other two in the ordinary way, and thin out one of these, damaging the plants by bruising as you do so, and leave the soil loose around the plants left in the ground ; thin out the third bed in the same manner, but sprinkle over it, as you go along, sand soaked in paraffin, so that the sand falls down and covers in the spaces around the young carrots. You will find the middle plot infested with "rust," the flies having been attracted by the smell from the bruised carrots ; the dressed plot and plot one will be practically clean, owing to the paraffin destroying the smell of the plant in the one case, and no smell being released in the other. The use of these deodorants is very important as a preventive of insect ravages, both for dressing the seed and young plants.

Thus from studying the structure of an insect we see that we can fight them in three different ways—by poisoning, by asphyxiating, and by destroying the natural smell of the plant. The corrosive action of certain substances must also be noted.

The two means of checking insect ravages are by Prevention and Remedies.—By prevention the appearance of any pest is forestalled, by either making the surroundings unfit for them to live in, by the winter destruction of the insects, by trapping, or by the use of deodorants upon seeds and seedlings. In regard to the *winter de-*

struction, which is one of the most important features in prevention, let us see where insects generally take up their winter quarters. After an attack of onion maggot, rust, celery fly, cabbage maggots, and wurzel fly, &c. (all of which are the larvæ of Diptera), we shall find in the ground during the winter numberless small, oval, brown bodies known as "puparia," each of which contains a pupa derived from one of the maggots. We must not forget, however, that some of the larvæ have not matured by the time the crop was lifted, and thus some are harvested with the crop, as we find in maggoty onions and rusty carrots ; or they may remain in the leaves, as in the case of celery-fly, or in the rotting stalks and roots, as in cabbage maggots. Now, if these are left in and on the ground and not destroyed, fresh generations appear next year, and should a similar crop be grown on or near the same land it stands a considerable risk of further attack. Again, in *sawfly larvæ* attack on fruit-trees, at the end of the year the larvæ fall to the ground, bury themselves a few inches beneath the bushes and trees, and forming a case of silk and earth, likewise later pupate. They often remain as larvæ in the cocoon until the spring, and then pupate. A very large number of moths also are found in the pupal stage in the earth in the winter time. At this time of year one and all should be destroyed. Two methods seem to recommend themselves—one, turning over the land so as to expose the pupæ to the attack of birds, which greedily devour them ; another, by deep trenching the land so as to bury the insects. After a bad attack of currant sawfly, we may remove the soil from beneath the currant and gooseberry bushes in winter and burn it in gardens.

It must be remembered that frost has little or no injurious effect upon insects in the egg or pupal state, or even upon most maggots.— I have known chrysalids frozen as brittle as glass, and yet their vitality was unimpaired. Frost, if anything, is beneficial to insect life, for the hard state of the ground protects the creatures from the attack of birds. Many insects hibernate in the adult state,—such as the turnip-flea, thrips, apple-blossom weevil, earwigs, &c.,—taking refuge in hedgerows, grassy headlands, rubbish-heaps, under dead bark, and so forth. Hedges bordering fields and gardens, and all grassy patches, should be well cleaned in the winter, the material burnt, and all rubbish cleared off and similarly destroyed. The dead leaves that collect in currant-bushes harbour the young larvæ of the currant moth (*Abraxas grossulariata*), and should therefore be cleaned out. *All prunings of fruit-trees should be burnt*, and not left about in heaps as we often see them, for numberless ova of psylla, aphis, lackey moth, and winter moth may be upon them ; a cursory examination with a lens will soon show their presence. Clean farming is the essential of insect prevention, and this especially applies to fruit. Examine in winter an old apple-tree covered with rough bark, moss, and lichens, and we may find numberless larvæ of the codling moth, American-blight insects, earwigs, weevils, &c., sheltering beneath. Cleaning the bark in winter will do away with many destructive creatures. Some insect enemies are found beneath the fruit-trees in the ground in winter, but some destructive species come into activity during the cold months of the year—namely, the *winter moths.* These moths appear from October to April, and lay their eggs upon the twigs and buds. The females are wingless in some (March moth), nearly so in others (Winter moth), and ascend the tree-trunks to deposit their eggs : the males, however, may carry a few up to the tree *in copulâ.* Those crawling up the trunk are easily captured by *grease-banding.* This method has now been in vogue for some time. *Banding of another sort is useful in gardens and orchards—namely, for codling moth larvæ.* The best plan for this pest is to tie round the trunk about a foot from the ground a wisp of hay or sacking in May : here the larvæ find a shelter in which to pupate, and can then be taken off with the sacking or wisp in the winter and burnt.

Another insect which may be trapped is the *click beetle,* the parent of the wireworm. This is done by placing small masses of green stuff, lucerne or sainfoin, under a board in gardens from April to July, when numbers of click beetles will be found sheltering beneath during the daytime, and may then be destroyed with the ova they have laid below the lucerne. *Leather-jackets* may also be caught by placing large lumps of rotting turf upon the ground where they are abundant.

Considerable damage is often done to fruit, peas, &c., in gardens by a group of beetles called Weevils (*Curculionidæ*). These beetles can always be told by their having a snout and elbowed antennæ (*vide* p. 154). They are destructive both in the imago and larval stages, the adults devouring leafage and the larvæ rootage of plants. Weevils are always extremely sensitive, and fall to the ground at the least shock, when they curl their legs in and feign death. The larvæ are always curved, white, wrinkled, footless grubs, and generally feed close to the surface during the winter months. Many weevils (*Otiorhynchus*) have no wings. This genus contains such noxious species as the raspberry weevils (*O. picipes* and *O. sulcatus*) and the plum weevils (*O. fuscipes* and *O. tenebricosus*). They all hide away during daylight, coming out at night to feed. We can best catch these depredators by "jarring" the trees over tarred sacks or boards at nights, when the weevils fall off and are caught in the tar beneath. Jarring may generally be employed for this group of beetles. Arsenical spraying is also said to kill them. Some other weevils (*Bruchidæ*) attack seeds, living in the larval state in them, such as the pea weevil (*Bruchus pisi*). All infested seed should either be steeped in carbolic water or fumigated with bisulphide of carbon for some hours, when all signs of insect life will be destroyed.

Such are some of the many ways by which we can prevent insect attack. *Cleanliness and the judicious rotation of crops will to a large extent keep them in check; whilst, where we can, such animals* as pigs, fowls, guinea-fowls, &c., may be employed on infested land after a bad attack, especially in orchards, where they will be seen greedily devouring all manner of grubs that come in their way.

Substances used for the destruction of insects, or *insecticides*, are now employed with great success.—*Insectifuges* are mixtures used for keeping insects off a crop — preventive washes or powders. Insecticides may be liquid or dry; the liquid washes are always preferable to the dry powders. To destroy insects by washes or spray fluids we must carry one thing in our mind—namely, How do the insects to be killed devour their food? are they provided with a biting or a sucking mouth?

There are six chief types of washes now in use—namely, (1) *Arsenical washes;* (2) *Tobacco washes;* (3) *Paraffin emulsions;* (4) *Sulphur lime washes;* (5) *Soft-soap and Quassia washes;* (6) *Caustic or winter washes.*

1. *Arsenical washes* are three in number—viz., Paris green, London purple, and Arsenate of lead. These poisonous washes are only of use for leaf-eating larvæ and beetles. As to the respective merits of each, arsenate of lead stands first, as it has a lesser tendency to burn the leafage, a feature which has too often attended the use of Paris green. *Arsenate of lead* is mixed in the following manner: dissolve 2 ounces of arsenate of soda (commercial) in a little water, then dissolve 7½ ounces of acetate of lead also in water. Add the arsenate of soda to 10 gallons of water, and then after stirring well add the dissolved acetate of lead and mix the whole well together. It may also be obtained as a paste (Swift's, Berger's, Voss', &c.)

Spray in early morning and late in the afternoon, unless on dull days. *Never spray when the blossom is out*, as it kills the bees. *Never leave the wash about*, as it is poisonous. *Three sprayings should be always employed—one just before the buds begin to burst, the second just before the blossom opens, and the third directly the blossom has fallen.* By so doing several insect attacks are dealt with, such as Winter moth, Tortrix, and Codling moth.

2. *Tobacco washes.*—Tobacco is one of the most potent insecticides. It may either be used in the form of a wash or mixed with camphor and used as a fumigant under glass. In many cases rag or paper steeped in tobacco-juice is used for burning in glass-houses to kill aphis, thrips, &c. It is best used as nicotine, but this is too expensive to use on a large scale. Nicotine wash is made as follows :—

Nicotine (90–98 per cent) . .	1 oz.
Soft-soap	2 oz.
Water	10 gallons.

Plain tobacco-leaf waste may also be used, or home-grown tobacco, as follows :—

Tobacco waste	2–3 lb.
Soft-soap	½–1 lb.
Water	10 gallons.

Infuse the tobacco waste in water, and press ; then add a pinch of soda, and add the whole to the dissolved soap and water. At present the only way tobacco wash can be used commercially is to buy it from insecticide makers.

3. *Paraffin washes.*—Paraffin-oil or kerosene forms an excellent insecticide and insectifuge, especially if it is used with soft-soap in the form of an emulsion, by which the paraffin is evenly distributed in the water. This wash is useful for celery fly, marguerite fly, scale insects, plant-lice, &c. Paraffin emulsion may be prepared by mixing equal proportions of boiling soft-soap solution and paraffin together, and thoroughly churning them until a thick creamy emulsion is formed. This emulsion can be kept and mixed with sixteen to thirty times its bulk of warm water when required for use. Another method is to dissolve 1 quart of soft-soap in 2 quarts of boiling soft water. Remove from the fire, and while still boiling hot add one pint of paraffin oil, and immediately churn the mixture with a small hand syringe for five minutes. For use dilute with ten times its volume of water (Cousins). By far the best mixture is paraffin jelly, made as follows : Paraffin, 5 gallons ; soft-soap, 8 lb. ;

water, 10 gallons. Boil together in a closed copper, and when boiling add a few pints of cold water. When all is dissolved, pour into a barrel or pails; it then solidifies to a jelly. Use 10 lb. of jelly to 40 gallons of water. Paraffin jelly is an excellent remedy for red-spider on fruit, for scale, aphis, and leaf hoppers.

4. *Lime-sulphur washes.*—The two following formulæ are the best for clearing trees in winter, for pear-leaf blister mite and some coccidæ (*Aspidiotus*). They do not kill insect eggs, as some say, nor are lime-sulphur washes at summer strength of much value as insecticides. For winter use only.

(1) *Lime-sulphur-soda wash*—

Lime	3 lb.
Sulphur	3 lb.
Caustic soda	1 lb.
Soft-soap	1 lb.
Water	10 gallons.

Make the flowers of sulphur into a paste with water, and then thin and pour over the lime; let this boil for a quarter of an hour, then stir and add the caustic soda; let this boil for some time, and then add the dissolved soap and full complement of water.

(2) *Lime-sulphur-soda-salt wash*—

Quicklime	3–6 lb.
Sulphur	3 lb.
Salt	3 lb.
Caustic soda	1 lb.
Water	10 gallons.

Mix soda and lime together, and slake with some hot water in which the sulphur has been incorporated, and then bring up to the full 10 gallons. This is self-boiling.

(3) *Lime-salt wash.* — This is useful for cleaning fruit-trees of moss, lichen, &c., and at the same time undoubtedly checks the hatching of apple sucker and plum aphis eggs. Moreover, both ingredients, as they get washed off, pass to the soil, and there do much good. It is made by slaking 1½ cwt. of the best white lime, and adding this, strained through a coarse sieve, to 100 gallons of water in which 15 lb. of salt has been dissolved. Use in March or late February, putting on as thickly as possible.

5. *Soft-soap and Quassia wash* forms a very useful cleansing wash for aphides. It is made of 1 lb. of soft-soap, 1 lb. of boiled quassia-chips to 10 gallons of water. The quassia should be boiled separately for two hours, with just sufficient water to keep it liquid.

The soft-soap should be also boiled, and then added to the strained extract of quassia; after both have been well mixed, they may be added to the 10 gallons of warm water.

6. *Caustic washes* are used with great success in the winter as agents for ridding the bark of trees of their vegetal incumbrances. The best wash is made by mixing 2½ lb. of caustic soda with 10 gallons of water. It must not be used until the sap is well down the tree. Trees washed with this soon present a clean healthy appearance, and can be told at once.

Fumigation.—This treatment is used for nursery-stock and plants under glass. For this purpose (1) Hydrocyanic acid gas is used, also (2) Tobacco, and (3) Pyrethrum. The first is most useful for nursery-stock and dormant plants—it kills all life.

For every 100 cubic feet of space use ⅔ ounce of potassium cyanide, and for each ounce of the cyanide use one liquid ounce of sulphuric acid, mixed with 4 ounces of water. The cyanide is dropped by special apparatus into the acid and water, and at once the deadly fumes arise. Plants are best treated in a dull light, dry temperature, and at about 60° F., and should be exposed to the fumes for at least an hour. The fumigating chamber or houses must not be entered until all the gas has escaped, and this should be allowed to do so from above. If sodium cyanide is used, then a ½ ounce is required. One must remember that this gas is a deadly poison, and so it must be employed with extreme caution.

Soil Fumigation.—In killing insects under ground, bisulphide of carbon is employed. It is injected into the soil by means of the Vermorel Injector at the rate of 4 ounces to the square yard, as many small injections as possible. Being heavier than air, it sinks into the soil, and is fatal to insect life that it reaches. It is also used for fumigating grain, &c., and must then be placed at the top of the grain. Remember it and its gas are poisonons and highly inflammable—no light, cigar, or live electric wire must go near it. Various patent soil fumigants, such as vaporite, fumite, and apterite, are used with success for most ground pests, as leather-jackets, chafer larvæ, surface larvæ, and ants.

The effect of artificial manures on insect pests is often most marked. Nitrate of soda and kainit are frequently of much service in destroying surface grubs, whilst on the other hand superphosphates have less effect. Bone-meal and guanos encourage many insect pests. Soot forms an excellent deterrent to many leaf-eating beetles and onion fly; dusting over the seed leaves and broadcasting over beds of pickling onions is nearly always followed by cessation of attack in such insects as onion fly, especially if it is broadcasted when there is dew on the leaves : at the same time it stimulates the plant to growth, and makes good the damage caused by the insects.

Infestation is often carried to gardens in dung and leaf-mould: these should be examined, and if found to be very foul, should be mixed with gas-lime if possible, and not used until the lime has done its work, and so purified the manure. I have seen many gardens infested in this way. Mould-heaps and peat-heaps should always have a dressing of lime on the top to keep off the daddy-long-legs, click beetles, &c., that will lay their eggs there if they get the chance. Lastly, every farmer and gardener should protect as far as he can the numerous insects that are beneficial, and the birds and animals that help to keep down our only too rapidly increasing insect pests.

The enemies of insects include such groups of insects as lady-birds, lace-wing flies, hover flies, ichneumon flies, tachina flies, sand-wasps, carabidæ or ground beetles, &c., described in previous chapters.

Besides insects, frogs, toads, and shrew-mice do much good in gardens, where they can be usefully employed ; and numerous birds are of the greatest benefit in checking insect depredations, notably the family of Tits or *Paridæ*, and many of the migratory birds. Even the thrush does good by destroying heaps of grubs, snails, and slugs, and so makes up for the loss it sometimes occasions amongst the fruit ; and the rook and starling kill the wireworm in the fields which as yet we cannot do, and the plover takes no toll and does infinite good.

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